FUNCTIONAL TRICUSPID REGURGITATION: MECHANISMS AND DETERMINANTS OF SEVERITY

AN ECHOCARDIOGRAPHIC STUDY

A dissertation submitted in partial fulfillment of

DM - Branch II Cardiology Examination of

the Tamilnadu Dr. MGR Medical University, Chennai,

to be held in July/August 2011

BONAFIDE CERTIFICATE

This is to certify that the work presented in this dissertation titled "**FUNCTIONAL TRICUSPID REGURGITATION: MECHANISMS AND DETERMINANTS OF SEVERITY**" done towards partial fulfillment of the requirements of the Tamilnadu Dr. MGR Medical University, Chennai, for the DM Branch-II (Cardiology) examination to be conducted in July/August 2011, is a bonafide work of the candidate Dr. John Jose. E, senior post-graduate student in the department of Cardiology, Christian Medical College, Vellore and was done under my guidance & supervision. This dissertation has not been submitted, fully or in part to any other board or university.

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DECLARATION

I, Dr. John Jose. E, solemnly declare that this dissertation entitled, "**FUNCTIONAL TRICUSPID REGURGITATION: MECHANISMS AND DETERMINANTS OF SEVERITY**" is a bonafide work done by me at the department of Cardiology, Christian Medical College, Vellore under the guidance and supervision of Dr. Oommen K George, Professor, Department of Cardiology, Christian Medical College, Vellore. This dissertation has not been submitted, fully or in part to any other board or university.

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ABSTRACT

Title: Functional tricuspid regurgitation: Mechanisms and determinants of severity

Background: Functional tricuspid regurgitation (TR) important clinical condition associated with significant cardiac mortality and morbidity. Mechanisms and determinants of functional TR severity have not been well established.

Study Aim: This prospective observational study was done with an aim to analyze the mechanisms of functional TR and to identify factors that independently determine its severity by transthoracic echocardiography in patients, aged 18 years and above, referred for echocardiography with various clinical indications.

Material and methods: Between May 2010 and December 2010, a total of 110 functional TR patients and 21 controls underwent comprehensive echocardiographic assessment using 2 and 3-dimensional echocardiography for determination of factors associated with TR severity, defined using standard criteria. Tricuspid annulus dimension, tricuspid valve (TV) tethering height, right heart geometry and function, left ventricular geometry and function, and systolic pulmonary artery pressure were assessed for significant association with TR severity.

Results: Of the total 110 functional TR patients, forty seven patients had severe regurgitation. Thirty three had mild TR and thirty had moderate TR. Rheumatic valvular heart disease was by far the most common clinical condition present in these patients. Functional TR severity was associated with several measurements of right ventricular and tricuspid annulus geometry, right atrial size, right ventricular function and estimated pulmonary artery systolic pressure by univariate analysis. Tricuspid annulus contraction percent, indices of left ventricular function and geometry were not associated with regurgitation severity. TV tethering distance ($p < 0.001$), end-diastolic tricuspid annulus dimension ($p=0.001$), right ventricular end-systolic eccentricity index (RV-ESEI) ($p=0.001$) and end-systolic right atrial area ($p=0.028$) independently determined functional TR severity by multivariate analysis. The sensitivity and specificity for predicting more than moderate TR were 98% and 95% with a tricuspid annulus end diastolic diameter value of > 3.59 cm, and 96% and 91% with a tethering distance > 0.79 cm respectively. With increasing severity of functional TR, TV annulus enlarges and assumes a relatively circular shape with a greater increase in the antero-posterior annulus dimension. Degree of tethering was found to correlate with functional TR severity in all the three leaflets ($p < 0.001$).

Conclusion: The role of TV annulus dilation and tethering of its leaflets in the pathogenesis of functional TR have been emphasized by this study. The study also provides valuable insights into the relationship between geometric alterations of the right sided cardiac chambers, tricuspid valve deformations and functional TR severity. Findings of this study have potential mechanistic and therapeutic implications, and will pave way for future research.

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CONTENTS

INTRODUCTION

Tricuspid valve (TV) plays a pivotal role in the pathophysiology of left sided valvular disease and heart failure. Tricuspid regurgitation (TR) may be due to primary defects of the TV or more commonly, to secondary factors resulting in functional regurgitation despite a structurally normal valve. The development of TR, whether organic or functional, is associated with significant morbidity and mortality. [1-4]

Only a few studies have been done on the mechanisms of functional TR which is in contrast to the numerous studies done for elucidating mechanisms of functional mitral regurgitation (MR). Consequently, mechanisms and determinants of functional TR severity have not been well established. Hence this observational study was done with an aim to identify the various factors that independently determine functional TR severity.

Management of functional TR has evolved from conservative approaches to a more direct approach such as TV annuloplasty. In 1967, a conservative approach to TR was proposed by Braunwald et al.[5] Proper correction of the left-sided heart pathology was presumed to reduce or even abolish functional TR. Subsequently, it has become apparent that resolution of TR might not occur after mitral valve surgery and may even become evident several years later.

In recent times, there has been an increased impetus to address functional TR, especially during surgery for left-sided heart pathology. Current approaches have provided unsatisfactory results.[6-10] A better knowledge of the mechanisms that operate in the pathogenesis of functional TR could potentially lead to improved treatment measures, especially surgical.

Data from prior studies suggest that annular dilatation of the TV and tethering of its leaflets mediates a key role in the generation of functional TR. At present, there is a paucity of data concerning the impact of morphological and functional changes of right side cardiac chambers and left ventricle, on the functioning and geometry of the TV. Since TV annulus is situated between right atrium and right ventricle, any pathology that affects either one of the chambers may have a significant effect on the functioning of the TV. Similarly TV is connected to the interventricular septum by the attachment of papillary muscles. Alterations of the left ventricular geometry and function may also impact on the function of TV because of ventricular interdependence or due to circulatory effects.

STUDY PURPOSE AND HYPOTHESIS

This prospective observational study was done to elucidate mechanisms and determinants of functional TR severity with the hypothesis that in addition to tricuspid annulus dilatation, other factors such as alterations of the geometry and function of the right side cardiac chambers or of the left ventricle play a crucial role in determining functional TR severity.

AIM AND OBJECTIVES

The present study, a prospective observational study, was undertaken with the following aim and objectives.

Aim:

The study aims to analyze mechanisms of functional TR and to identify factors that independently determine its severity by 2 and 3-dimensional transthoracic echocardiography in patients, aged 18 years and above, referred for echocardiography with various clinical indications.

Objectives:

1. To enumerate the etiological spectrum of functional TR diagnosed by echocardiography at a tertiary medical center.
2. To identify factors associated with varying degrees of functional TR.
3. To elucidate the anatomic, geometric and hemodynamic determinants of functional TR severity and to describe the potential mechanisms.
4. To obtain data regarding tricuspid annulus dimension and deformations in patients with functional TR.
5. To describe the distribution of TR severity in relation to pulmonary artery systolic pressure estimated by echocardiography and to identify factors associated with TR severity in patients with pulmonary artery hypertension.

FUNCTIONAL TR: ANATOMIC CONSIDERATIONS

TV is the most apically positioned heart valve and has an intricate anatomic structure comprising of leaflet tissue (anterior, posterior and septal leaflets), supporting annular ring, chordae tendinae, papillary muscles, right atrium and right ventricular myocardium (figure 1).[11] Structural integrity and coordination of these components are needed for successful functioning of the TV.

A. ***Valve leaflets.*** The three TV leaflets are of unequal size are attached to a fibrous annulus. The anterior leaflet is the largest and extends from the infundibular region to the inferolateral wall. The septal leaflet is the smallest and arises directly from the tricuspid annulus above the interventricular septum and extends to the posterior ventricular border. The posterior leaflet has multiple scallops and is attached along the posterior margin of the annulus from the septum to the inferolateral wall.

B. ***Tricuspid annulus***. The tricuspid annulus has a complex 3-dimensional structure, shape of which has implications for the design and application of currently available annuloplasty rings. The annulus has a non-planar elliptical structure, having two high points oriented rostrally towards the right atrium and two low points which are oriented inferiorly toward the right ventricle.[12] Maintenance of TV competence is also maintained by the normal motion and contraction of the annulus. The tricuspid annulus dilatation occurs primarily in its anterior-posterior aspect, as the septal wall leaflet is fairly fixed and has little room for movement. The tricuspid annulus septal aspect may thus be considered to be analogous to the intertrigonal portion of the mitral annulus, which is also spared from annular dilation.

Thus dimensions of the base of the septal leaflet forms the basis of tricuspid annular sizing algorithms.

C. ***Papillary muscles and Chordae.*** The chordal attachments to the anterior and posterior leaflets are provided by the anterior papillary muscle. The posterior and septal leaflets receive chordae from the medial papillary muscle. The anterior and septal leaflets receive chordae from the septal wall. Accessory chordal attachments to the moderator band and right ventricular free wall may additionally be present which can impair proper leaflet coaptation in the setting of right ventricular dysfunction and dilation.

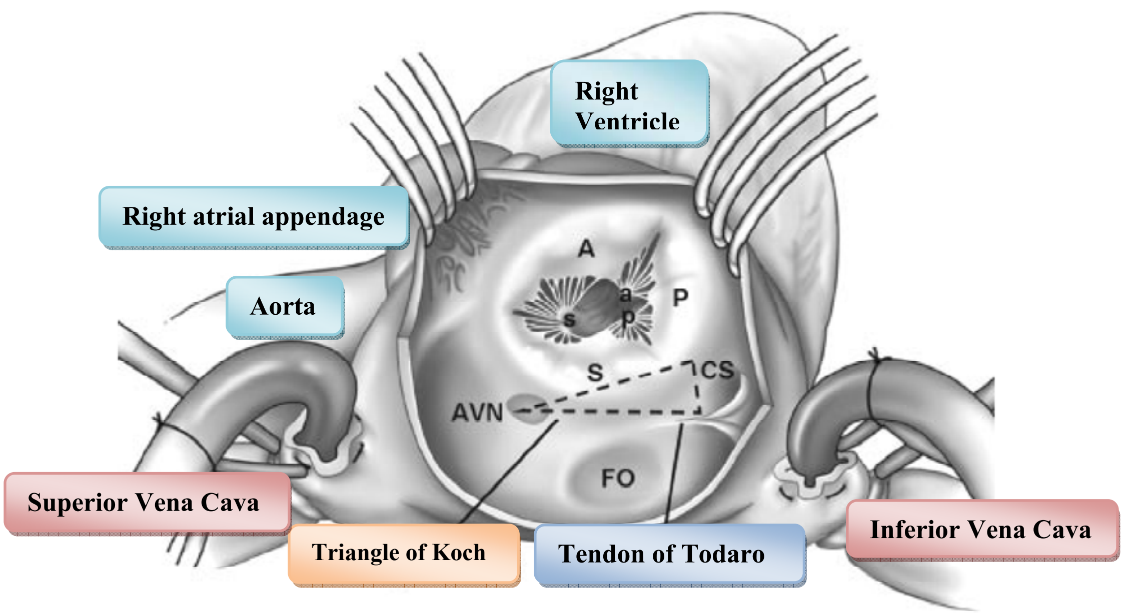

Figure 1. Tricuspid Valve Complex: The TV consists of anterior (A), posterior (P), and septal (S) leaflets, muscles, anterior (a) and posterior (p) and rudimentary septal (s) papillary muscles and chordae tendinae. AVN represents the atrioventricular node; CS, coronary sinus ostium; FO, foramen ovale. *(Adapted with permission from Wolters Kluwer Health)*

HISTORICAL PERSPECTIVE

Historically, concomitant repair of the TV during surgery for left heart valve lesion was less commonly performed because of the observation that functional TR often improves after such surgery. Braunwald et al[5] analyzed hemodynamic data before and after procedure in 28 patients with severe TR who had mitral valve replacement (of which only three underwent tricuspid annuloplasty). The authors concluded that mitral valve replacement alone leads to resolution of severe functional TR in most patients and therefore TV surgery was not indicated. This remained the dominant clinical view and practice for a long time.

Carpentier et al[13] advanced the opposing view of routine valve repair for functional TR and was almost universally ignored. Subsequently, with the widened application of cardiac surgery in the early 1970s, there became an increasing population of long term survivors of prosthetic mitral valve replacement. Several investigators then began to observe that many of these patients developed late heart failure as the result of severe TR. When such patients were re-operated for repairing or replacing the TV, high mortality was observed. These observations lead many investigators to follow a liberal approach to annuloplasty at the initial mitral valve operation. Contemporary evidence suggests that TV repair should be considered more often.

TRICUSPID REGURGITATION: ETIOLOGIES

Etiology of TR can be physiologic or pathological (table 1). Pathological TR can be organic (primary TR) or functional (secondary TR). Pathologic TR is more commonly functional, occurring secondary to left heart failure due to myocardial or valvular causes, right ventricular pressure overload, and enlargement of cardiac chambers.

A. ***Physiologic TR.*** Small degrees of TR are frequently encountered in normal individuals.[14] These patients have normal valve morphology without any abnormality of the right ventricle on echocardiography. Physiologic TR is characterized by a thin central jet with peak systolic velocity of 1.7 to 2.3 m/s, confined to a small region adjoining the valve (<1 cm), and may not extend throughout systole.[15]

B. ***Organic TR.*** Organic TR is related to direct involvement of TV by disease process and accounts for only 8-10% of severe TR.[2] These primary disease processes include, infective endocarditis, carcinoid syndrome, congenital defects like Ebstein's anomaly or Atrioventricular Canal defects, myxomatous degeneration with prolapse, trauma and iatrogenic damage (during heart surgery, biopsy and right heart catheter manipulation).[15]

C. ***Functional TR.*** TR is said to be functional in a majority of patients. Functional TR is the result of adverse effects on RV function and geometry caused by left-sided heart valve diseases, pulmonary hypertension, congenital heart defects, and cardiomyopathy.

Etiology of Tricuspid regurgitation	
Physiologic TR	
Pathologic TR	
Primary (organic)	
Acute	Infective Endocarditis Traumatic (blunt chest injury, laceration) Iatrogenic (pacemaker/defibrillator leads, right ventricular biopsy) Anorectic drugs Papillary muscle dysfunction/ rupture
Chronic	Rheumatic heart disease Myxomatous degeneration Carcinoid Syndrome Ebstein's anomaly Endomyocardial fibrosis
Secondary (functional)	
	Left heart disease (Left ventricular dysfunction or valve disease resulting in pulmonary hypertension) Any cause of pulmonary hypertension (chronic lung disease, pulmonary thromboembolism, left to right shunt, idiopathic etc) Any cause of right ventricular dysfunction (myocardial disease, right ventricular ischemia or infarction)

Table 1. Etiology of Tricuspid regurgitation

EPIDEMIOLOGY AND PROGNOSTIC IMPLICATIONS

Incidence

Mild physiologic TR is often observed in healthy individuals and has a prevalence of 65–75%.[14] Functional TR has a reported prevalence between 25% and 30% in patients undergoing left-sided valve surgery.[16-18] Thirty percent of patients with cardiomyopathy have functional TR and its presence is considered a marker of poor prognosis.[2,3,19] Nearly one-third of rheumatic mitral stenosis patients have more than mild functional TR.[4] The incidence of significant TR in those undergoing surgery for functional MR was 14% in a study.[20] Similarly, in valve prolapse related MR subjects, the incidence was 15% at the time of procedure.[21] In a recent report, McCarthy et al[7] reported 32% prevalence of > 2+ TR on pre-operative echocardiography for patients having mitral valve procedures. Clinically severe TR occurs in 23% - 37% of patients after valve surgery for rheumatic mitral valve disease.[22-24] Dreyfus et al[25] reported 34% late significant TR in a small cohort of patients with varied etiologies for MR. Significant TR was observed in nearly 74% of patients three years after ischemic MR repair.[9]

Impact of TR on survival and morbidity

In a large cohort study of 5507 patients who had echocardiography at the Veterans Affairs Health Care System, Nath et al[2] found that TR of any etiology was associated with inferior survival. The survival for patients with severe regurgitation was 64% compared with 90% in those with no regurgitation at one year. Even after adjusting for age, ventricular function, moderate (hazard ratio, 1.17) and severe (hazard ratio, 1.31) TR remained predictive of long term mortality compared with those who had no TR. However this was a purely echocardiographic study of predominantly male Veterans Administration patients and the indications for the echocardiogram, presence of other valve dysfunction or cardiac pathology, and clinical history of the patients were not reported.

Lee et al[26] in a more recent study observed a five year survival of 74% for patients with more than mild grade uncorrected isolated TR. Survival was worse in subjects with pulmonary hypertension or decreased right ventricular function in this study.

Ruel et al[27] reported moderate to severe TR to be an independent determinant of clinical events such as advanced cardiac failure, cardiac failure related mortality, and even all cause mortality during five year follow-up in a study. However, only 77% of the study subjects had echocardiographic follow up. Five year survival of 50% was reported after mitral valve surgery in rheumatic patients having severe TR, whereas mortality was nil in mild TR subjects.[28]

The quality of survival is also compromised by TR. Patients who develop TR after left heart valve replacement have a reduced exercise capacity.[29] The presence of significant TR after mitral valve replacement was shown to predict New York Heart Association (NYHA) functional class III or IV at follow up.[27] As compared with mild TR patients, those having moderate or severe TR prior to mitral valve replacement are more likely to have advanced congestive cardiac failure at late follow up (56% vs. 14%).[30]

Poor outcome with increased perioperative deaths, poor late survival and functional status are observed in those who undergo isolated TV surgery for severe TR after mitral valve replacement.[16,31-33] Perioperative mortality is usually between 11% and 20%, but can be as high as 50%.[31,33-35] Mangoni et al[31] reported operative mortality of 20% with a median survival of 1.2 years in patients who had isolated TV replacement. Of the patients who survived in this study, 50% had NYHA class III or IV.

MECHANISM OF FUNCTIONAL TRICUSPID REGURGITATION

The pathogenesis of functional TR is considered to be complex and multifactorial. Pathologic process such as ischemia or rheumatic involvement of mitral valve leads to regurgitation or stenosis, resulting in elevated left atrial pressure and, if significant enough, can cause elevated pulmonary artery pressures. Right ventricular dysfunction and remodeling follows long standing pulmonary hypertension, and can result in tricuspid annulus dilatation and papillary muscle displacement with tethering of the leaflets. This in turn leads to significant TR (figure 2).[8,36-39]

TR itself can cause further right ventricular dilatation and dysfunction with larger degree of annular dilation and leaflet tethering, and thus increasing the magnitude of regurgitation. The right ventricle significantly dilates and eventually fails with worsening TR. Right Ventricular diastolic pressure then rises and can shift the ventricular septum toward the left. Because of ventricular interdependence, septal shift results in restricted left ventricular filling and thereby elevating left ventricular diastolic and pulmonary artery pressures.[35]

Left atrial enlargement or elevated left atrial pressure can predispose to atrial fibrillation. Atrial fibrillation can cause dilatation of right atrium resulting in further dilation of the tricuspid annulus. Atrial fibrillation is an important risk factor for the occurrence of TR in patients with left heart valve lesions. It is also associated with occurrence and persistence of TR after balloon mitral valvotomy or mitral valve surgery.[40-42] Significantly less TR has been reported at follow up in patients who had successful Maze procedure along with mitral valve surgery. [43]

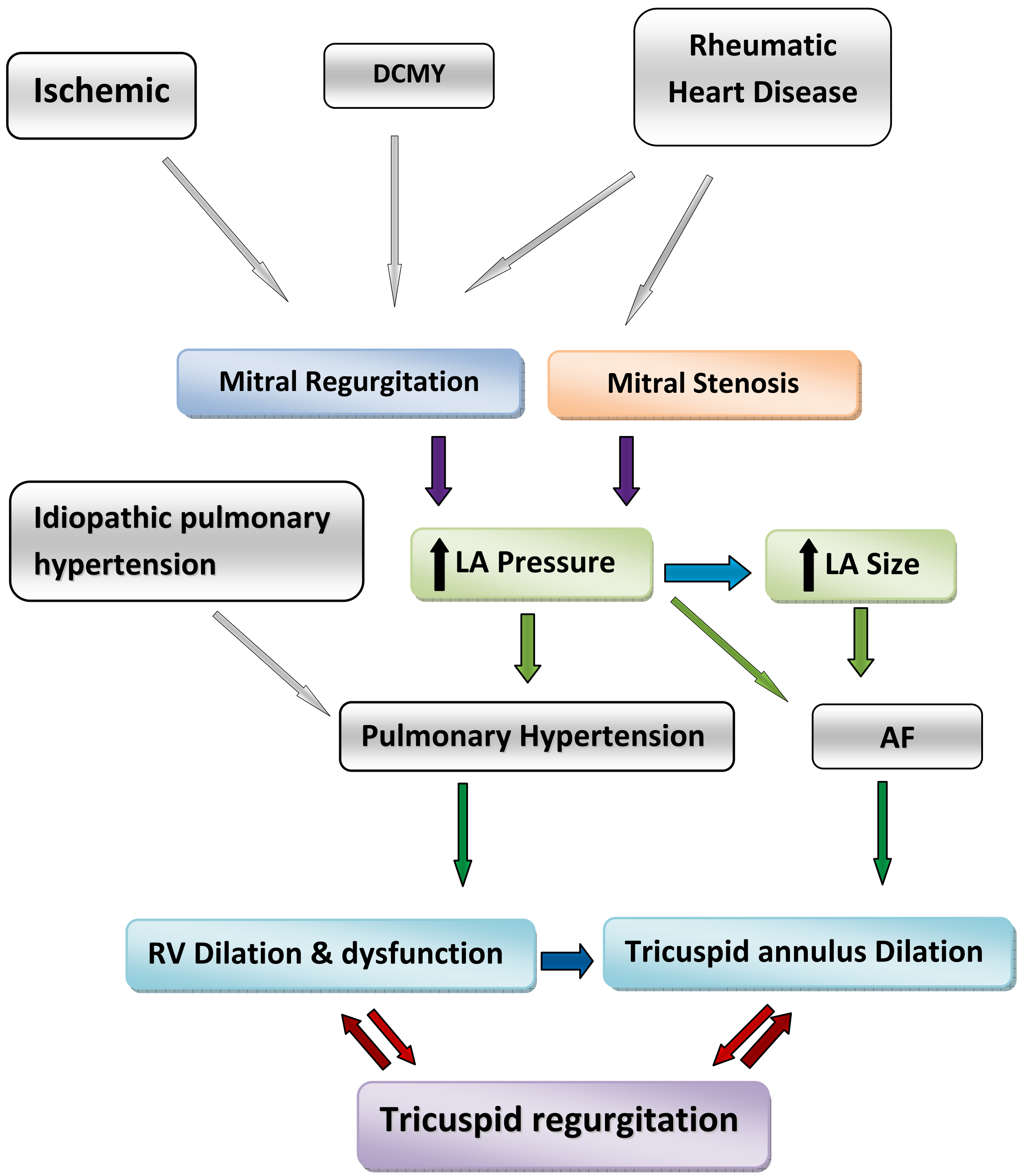

Figure 2. Pathogenesis of Functional TR in Mitral Valve Disease
DCMY stands for dilated cardiomyopathy; RV, right ventricle; AF, atrial fibrillation and LA, left atrial; *(Adapted with permission from Elsevier).*

Even though pulmonary hypertension is considered to be important in the mechanism of late TR, it may not be elevated prior to mitral valve surgery.[29] Pre-surgical pulmonary artery pressure did not predict late TR in a study by Porter et al.[23] Kaul et al[44] studied moderate functional TR subjects who had mitral valve replacement and reported lower incidence of late TR in severe pulmonary hypertension group when compared to those who hadn't. They also had better functional capacity and survival. Non severe pulmonary hypertension group had worse right ventricular function in this study. Right ventricular function can predict outcomes in mitral valve disease patients with TR.[33,45] The worse RV function in the non severe pulmonary hypertension group could have influenced the results. Another explanation is that these patients might have had organic TR rather than functional.

One of the key factors in the genesis of late TR is tricuspid annulus dilatation and this is also the target for current surgical approaches. The tricuspid annulus becomes enlarged and the normal saddle shape becomes a more planar and circular structure with a decreased medio-lateral to anteroposterior ratio in functional TR.[12,46] With increasing severity of functional TR, tricuspid area has been found to increase with reduction in the excursion of tricuspid annulus (29.6% in normal valves to 14.6% in patients with severe TR).[46]

The tricuspid annulus flattening which occurs in significant TR subjects alters the normal papillary muscle to leaflet and annulus relationship leading to stretching of the low points of the annulus away from the papillary muscles (figure 3). This can result in increased tethering of the leaflets and worsening TR.

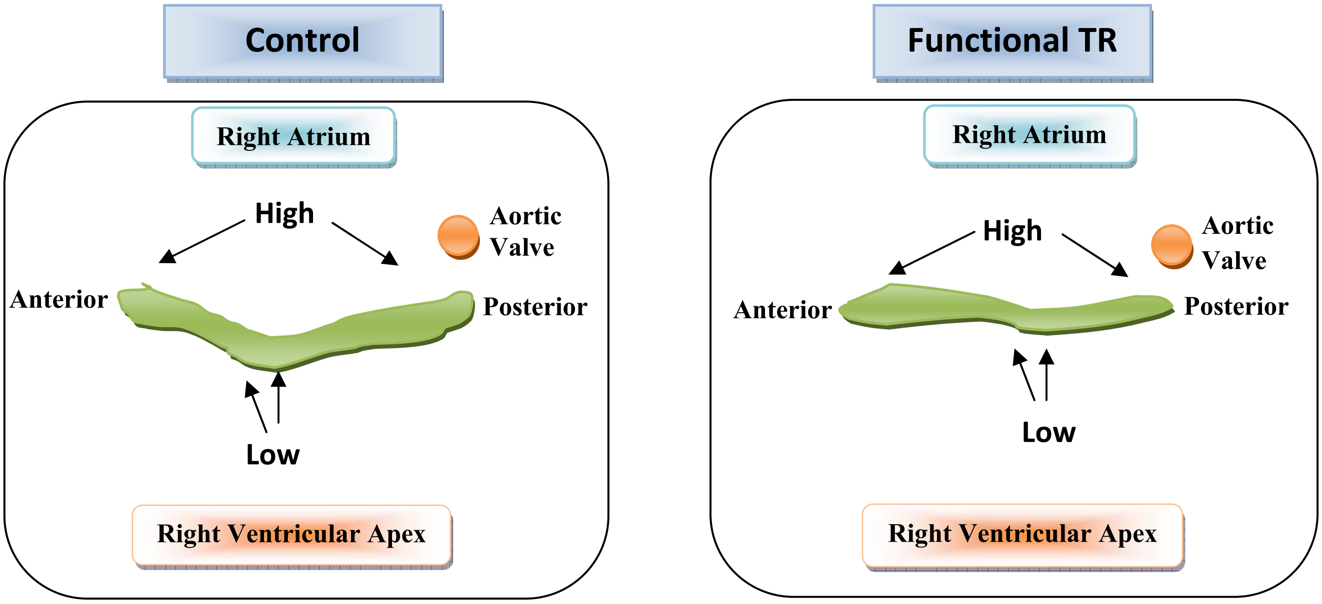

Figure 3. Tricuspid annulus. Left: control patient (normal tricuspid valve) with two high points located anteroposteriorly. Right: Functional TR patient where the annulus becomes flatter with no distinct high-point.

Right ventricular geometry can be altered by various pathologies and can cause functional TR independent of TA dilatation. As mentioned earlier right ventricular dilatation results in papillary muscle displacement leading to increased tethering of the TV leaflets which in turn leads to TR. Strong correlation exists between tethering of leaflets and persistent TR after ring annuloplasty.[8] Right ventricular eccentric enlargement has been associated with functional TR severity.[47]

FUNCTIONAL TRICUSPID REGURGITATION SEVERITY: INSIGHTS FROM PREVIOUS STUDIES

Insight from 2-dimensional Echo studies

In the early Nineties, Sagie et al[39] investigated 109 patients with incomplete TV apposition using color flow Doppler and evaluated the factors associated with severity of TR. Sixty seven percent of the study subjects had severe TR. The only independent determinant of severity of TR in this study was dilation of the tricuspid annulus. A significant greater apical displacement of the tricuspid valve in subjects with severe TR was observed by the investigators at study completion ($p < 0.02$). High pulmonary artery pressures and right ventricular enlargement did not correlate with severity of TR in this study. Authors also suggested that changes of the right ventricular shape rather than size to be important in the pathogenesis of TR.

More than a decade later, Kim et al[47] published a pioneering study substantiating the suggestion made by Sagie et al. Their study underscored the importance of alterations in right ventricular shape for predicting functional TR severity. The best correlation with the functional TR severity was shown by right ventricular end systolic eccentricity index, a novel echocardiographic measurement reflecting alterations in the right ventricular shape. Other parameters which independently predicted severity in this study was end diastolic tricuspid annulus dimension and tricuspid valve tethering area. As observed by Sagie et al, neither right ventricular enlargement nor pulmonary hypertension was found to be a pre- requisite for functional TR.

Fukuda et al[48] assessed relationship between functional TR severity and tricuspid valve deformations in a retrospective analysis of echocardiographic images of functional TR patients enrolled in the database of the Cleveland Clinic Foundation. Right atrial area, right ventricular spherical index and tricuspid valve tethering height independently predicted functional TR severity in this study. TA dimension did not predict severity in this study. Right ventricular area and spherical index, left ventricular function and right atrial area were shown to influence tricuspid valve tethering height in this retrospective study.

Seo et al[49] evaluated the mechanisms of isolated TR in patients without significant pulmonary hypertension and found it to be associated with right ventricular remodeling, right ventricular systolic dysfunction, dilatation of the TA and tethering of the TV leaflets.

Zhou et al[50] found atrial fibrillation to be associated with significant annular dilation and regurgitation. Atrial fibrillation can cause significant right atrial dilatation which in turn can potentially cause dilatation of the annulus situated between the atrium and the ventricle.

Insight from 3-dimensional Echo studies

Ton-Nu et al[12] studied the three dimensional geometry of the TV in patients with functional TR and noted two key findings. They described normal tricuspid annulus to be of saddle shape with high points situated in an anteroposterior orientation. Annulus was found to become more flatter and circular with a decreased mediolateral to anteroposterior ratio in patients with functional TR. As mentioned earlier, this results in increased tethering and regurgitation.

In another three dimensional echocardiographic study in patients with pulmonary hypertension, Sukmawan et al[51] found enlargement of the tricuspid annulus tenting volume and diameter to be associated with functional TR.

In yet another study by Fukuda et al,[46] investigators noted an increase of tricuspid annulus area and diminution of tricuspid annular excursion with functional TR. The decrease in excursion was most prominent in the severe TR group (14.6% versus 29.6% in healthy subjects, $p = 0.001$).

Park et al[52] determined the angles between the TV annulus plane and the three leaflets and found the angle between septal leaflet and tricuspid annulus plane, pulmonary artery systolic pressure and septal lateral diameter to be independent determinants of TR severity.

What factors determine severity of residual functional TR after left sided heart surgery?

Song et al[53] observed the development of significant TR without prosthetic valve dysfunction, in subjects who had undergone uneventful left heart valve surgery. Factors associated with the progression of TR in their study were advanced age, female gender, rhythm, rheumatic etiology and pulmonary hypertension.

What factors determine severity of residual functional TR after tricuspid annuloplasty?

Tricuspid valve annuloplasty is now performed in many centers if the annulus is significantly dilated at the time of left heart surgery irrespective of the grade of TR. However, TR can persist and even progress in many of these patients. Such residual TR occurs in 10-20% of subjects early after tricuspid annuloplasty.[54,55]

Fukuda et al[8] investigated the factors associated with residual TR after tricuspid annuloplasty. In their study, TV tethering was observed to be the independent predictor of residual regurgitation early after annuloplasty. In a recent three dimensional echocardiographic study, Min et al[56] evaluated the predictors of residual TR after annuloplasty. Pre annuloplasty tenting (tethering) volume and the tricuspid annulus dimension were observed to be the only independent predictors of severity.

CLINICAL ASSESSMENT OF TRICUSPID REGURGITATION

Functional TR may present with symptoms related to underlying etiology or with features of right heart failure and low cardiac output state in advanced stages. Rarely severe TR can remain asymptomatic for several years. Prominent physical findings are related to the regurgitant murmur and right heart failure. In the advanced stages, patients may present with cachexia, cyanosis and jaundice.

The classic triad of tricuspid regurgitation includes prominent 'V' in jugular venous pulse, pulsatile liver and systolic murmur exhibiting Carvallo's sign.[57] However the classic triad could be appreciated in only 42% of severe TR patients confirmed by right ventriculography in a study.[58] See-saw movement of the precordium (hyperdynamic left parasternal systolic lift and retraction, accompanied by right parasternal lift), has been described in clinically significant TR.[59,60]

Chest radiograph findings vary from normal sized right atrium to grossly enlarged right atrium depending on the degree of regurgitation. Electrocardiographic findings include atrial fibrillation and evidence of right sided chamber enlargement. Indirect and non specific evidence of TR include qR configuration in lead V1 and low amplitude QRS complex in lead V1 compared to lead V2.[61] Classic finding of TR during cardiac catheterization is the 'ventricularization' of the right atrial pressure curve.[57] Other findings include a large 'V' wave with a prominent y descent. This finding is accentuated during inspiration because of the physiologic increase in venous return. Main diagnostic tool for evaluation of TR is echocardiography. Cardiac Magnetic Resonance imaging is useful when echocardiographic evaluation is not conclusive for TR severity assessment and for assessing right ventricular size and function.

GRADING OF TRICUSPID REGURGITATION SEVERITY

Assessment of functional TR severity and its grading is mainly done by echocardiography. Several echocardiographic parameters can be used to assess TR severity. These include quantitative parameters such as effective regurgitant orifice area, regurgitant volume, regurgitant fraction, vena contracta width and flow convergence width. Qualitative parameters include jet density and contour, pattern of hepatic vein flow and supportive parameters such as enlargement of right atrium and ventricle, and inferior vena cava. Grading of TR integrating various European and American guidelines and is summarized in table 2.[62,63]

One of the main limitations for grading TR severity is the lack of a quantitative standard. Each of the mentioned methods has its own advantages and disadvantages and guidelines recommend integration of various parameters while grading regurgitation severity. Table 3 summarizes the strengths and disadvantages of various parameters used in the grading of TR.

Parameters	Mild	Moderate	Severe
Jet area (central jet), cm^2	<5	5-10	>10
Vena Contracta width, mm	Not defined	< 7	≥ 7
PISA radius, mm	≤5	6-9	≥ 9
Effective regurgitant orifice area, mm^2	Not defined	Not defined	≥40
Regurgitant Volume, ml	Not defined	Not defined	≥45
Hepatic vein flow (systole)	dominance	blunting	flow reversal
Jet density, contour	Faint parabolic	Dense parabolic	Dense triangular, early peaking
Tricuspid inflow E wave velocity	Normal	Normal	≥1 cm/s

Table 2. Grading of severity of TR. *PISA stands for proximal isovelocity surface area.*

Parameters	Advantages	Limitations
Vena Contracta width method	*Relatively quick and easy * Relatively independent of hemodynamic and instrumentation factors *Not affected by other valve leak *Good for extremes TR: mild versus severe * Can be used in eccentric jet	*Not valid for multiple jets *Small measurement errors leads to large % error *Intermediate values need confirmation *Affected by systolic changes in regurgitant flow
PISA method	* Can be used in eccentric jet * Not affected by the etiology of TR or other valve leak * Quantitative: estimate lesion severity (Effective Regurgitant Orifice Area method) and volume overload (Residual Volume) * Large flow convergence at 28 cm/s alerts to significant TR	* PISA shape affected – by the aliasing velocity – by systolic changes in regurgitant flow – by adjacent structures (flow constrainment) * Errors in PISA radius measurement are squared * Inter-observer variability * Validated in only few studies
Hepatic vein doppler	* Simple * Systolic flow reversal specific for severe TR	Affected by right atrial pressure, atrial fibrillation
Color flow jet	* Ease of use * Evaluates the spatial orientation of TR jet * Good screening test for mild vs. severe TR	* Can be inaccurate for estimation of TR severity * Influenced by technical and hemodynamic factors * Underestimates eccentric jet adhering the right atrial wall (Coanda effect)

Table 3. Advantages and limitations of different parameters used for grading of severity of TR. *PISA stands for proximal isovelocity surface area.*

SURGICAL MANAGEMENT OF FUNCTIONAL TRICUSPID REGURGITATION

Current practice patterns and guidelines for the management of TR and its evidence base

The current practice recommendations by the American College of Cardiology (ACC) and American Heart Association (AHA)[62], and European Society of Cardiology (ESC)[63] are summarized in the table below (table 4). The agreement among the two guidelines is limited to the recommendation that severe TR should be treated in those who undergo left heart surgery (Class 1 recommendation).

Guidelines for TV Repair for Functional TR according to the ACC/AHA and the ESC[62,63]	
ACC/AHA (2008)	
Class (I) :	Severe TR in those who undergo mitral valve surgery (B)
Class (IIb):	"Less than severe TR" in those who undergo mitral valve surgery, with pulmonary artery hypertension or tricuspid annular dilatation (C)
ESC (2007)	
Class (I) :	Severe TR in those who undergo left-sided valve surgery (C)
Class (IIa):	Moderate TR with annulus dimension >40 mm in those who undergo left heart valve surgery (C)
Class (IIa):	Symptomatic severe TR late after left heart valve surgery without left sided myocardial, valve, or right ventricular dysfunction or severe pulmonary hypertension (C)

Table 4. Indications for TV Repair in Functional TR

Surgical management

Goals of surgical management include correction of annulus dilatation, afterload reduction (reduction of pulmonary pressure by correction of left sided pathology) and tackling right ventricular dysfunction. Tricuspid annuloplasty done with an aim to restore tricuspid annulus geometry is the current standard procedure for functional TR. Two main approaches for annuloplasty are the suture and ring annuloplasty (figure 4).

Annuloplasty techniques

Suture annuloplasty techniques are modifications of either bicuspidization (posterior plication technique) or De Vega annuloplasty. De Vega procedure involves plication of both the posterior and anterior annulus from the posterior extremity of the septal portion of the annulus upto the anteroseptal commisure. Durability of suture annuloplasty became an issue (tendency for suture dehiscence) for De Vega’s procedure and this was partially corrected by Antunes and Girdwood’s modification in which a Teflon pledget was used to buttress each suture. Because of high rates of recurrence and residual TR, suture annuloplasty techniques have been largely abandoned (table 5).

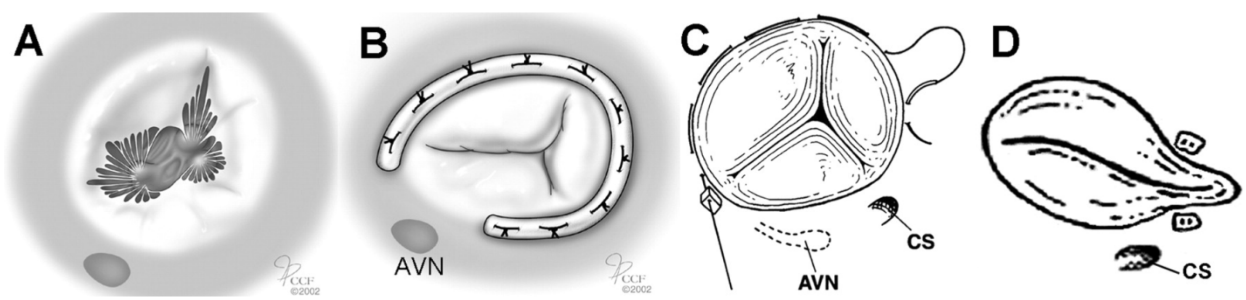

Figure 4 . Surgical techniques for functional TR. (A) Dilated tricuspid annulus. (B) Rigid annular bands restore normal size and shape. (C) De Vega annuloplasty (D) Suture *(Adapted with permission from Wolters Kluwer Health)*

Ring annuloplasty is now considered by most surgeons as the procedure of choice among the various annuloplasty techniques for dilated tricuspid annulus. Advantages of ring and band annuloplasty include better distribution of the tension on the annuloplasty suture line, more standardized annular reduction and the ability to differentially plicate the annulus. Rings may be rigid, semi rigid or flexible, partial or complete.

	Bicuspidization	Classic De Vega	Flexible band	Rigid ring
Simplicity	Simple	Simple	No	No
Annular stabilization	Posterior	Anterior / posterior	Anterior / posterior	Septal/ anterior/ posterior
Residual TR	High	Moderate	Low	Low
Recurrent TR	High	Moderate	Low	Low
Reproducibility	Low	Moderate	High	Very High
Added time	< 5min	<10min	10-20 min	15-20 min

Table 5. Comparison of various annuloplasty techniques

Tricuspid Valve replacement versus repair

Better midterm survival (up to 10 years post surgery) is observed with TV repair compared with replacement. However there are no significant differences with regards to re-operation or valve related mortality.[64] Hypothesis for the difference in survival is that a rigid mechanical valve in a low pressure deformable chamber like the right ventricle can result in ventricular dysfunction and a low cardiac output state. Potential thrombotic complications of mechanical and bioprosthetic valves can be avoided by choosing TV repair.

Newer Advances and future perspective of TV surgery

Low 30- day mortality of 2.1% and a good repair rate (61%) were observed for minimally invasive TV surgery using mini thoracotomy.[65] Successful implantation of percutaneous TV that consisted of a bovine jugular venous valve mounted to a nitinol frame has been described by Boudjemline et al[66] in normal sheep. In future, Alfieri type edge to edge percutaneous repair may have a potential role for the management of functional TR.

RELEVANCE OF THE PRESENT STUDY

From the preceding discussion, it is clear that functional TR is an important clinical condition contributing to significant morbidity and mortality in patients with left sided heart pathology. Management of this condition is difficult and challenging as many patients present with advanced heart failure and diminished right ventricular function. As mentioned above, functional TR can appear late or even progress after correction of left sided pathology. Relationship between geometric changes of the right sided chambers, left ventricle, tricuspid valve deformations and severity of functional TR are unclear due to limited studies on this topic. Hence, a better knowledge of the mechanisms involved in the pathogenesis of functional TR could lead to improved treatment measures. This study, a prospective observational study, aims to address and clarify some of the earlier mentioned lacunae in the current understanding of the mechanisms of functional TR. This study is likely to give mechanistic insights into the pathogenesis of functional TR; findings which may have potential therapeutic implications.

STUDY DESIGN AND METHODOLOGY

STUDY DESIGN

The study was a single center prospective observational study done over a period of eight months.

The study was performed in accordance with the Declaration of Helsinki and its subsequent amendments, and within the framework of Good Clinical Practice. The study was approved by the hospital's Research and Ethics Committee. The results of the study are reported adhering to the guidelines and addressing the checklist of the recent STROBE statement for observational studies (available at *http://www.strobe-statement.org*).

SETTING

The study was done in the Echocardiography lab of the Cardiology department of the Christian medical College Hospital, a 2500 bedded tertiary care hospital in South India. Echocardiography lab performs nearly 100 echocardiographic examinations per day for various clinical indications.

STUDY PARTICIPANTS

Inclusion criteria:

Patients aged 18 years and above, referred for echocardiography with various clinical indications and detected to have functional tricuspid regurgitation.

Exclusion criteria:

The study excluded subjects who met the following criteria.

1. Echocardiographic window which was suboptimal for a complete quantitative assessment of the tricuspid valve or the right ventricle.
2. Prior TV repair or replacement.
3. Acute right ventricular Dilation.
4. Cardiac tamponade.
5. Organic tricuspid valve disease.
6. Permanent pacemaker implantation.
7. Congenital heart disease and patients with evidence of right ventricular outflow tract obstruction.

Study Controls:

In addition, subjects who had sinus rhythm and no cardiac abnormalities were included for comparison of baseline parameters and to provide an estimate of normal values for various echocardiographic parameters.

OUTCOME MEASURES AND VARIABLES

Data Collection

Standardized documentation sheets were used and data was collected exclusively by the primary investigator (Annexure I). Detailed clinical examination was done on all patients and relevant data was charted. Enrolled patients underwent comprehensive 2-dimensional, 3-dimensional and Doppler echocardiographic evaluations.

Echocardiographic evaluations and definitions

Echocardiographic evaluation was done in a systematic manner using an echocardiography machine (Philips iE 33 Ultrasound machine, Philips Medical System). All examinations were recorded for off-line analysis. ECG gated images and loops were acquired in parasternal and apical views using a 1.0 -5.0 MHz sector array probe. The values of various echocardiographic parameters recorded were averaged over three cardiac cycles in sinus rhythm patients and five cardiac cycles in those who had atrial fibrillation. Three dimensional datasets were acquired during a breath-hold with ECG gating using 1.0-3.0 MHz Philips X3-1 matrix Array transducer. Data sets were analyzed using dedicated software (4D Cardio-View™, image arena platform, Tomtec imaging systems, Munich, Germany and QLAB, Advanced Ultrasound Quantification Software, Philips)

The following variables were measured by echocardiography.

A. **Right ventricular Geometry**

   a. **Right ventricular end-systolic and end-diastolic eccentricity index (figure 5).** These indices were measured in the parasternal short axis view at the level of left ventricular papillary muscle.[47] Eccentricity index was defined as the ratio of the longest right ventricular distance (line ‘a’ in the figure 5) to the distance between ventricular septum and right ventricular free wall at the midpoint of the septum (line ‘b’ in the figure 5). This was measured at end-systole and end-diastole to obtain the respective eccentricity index.

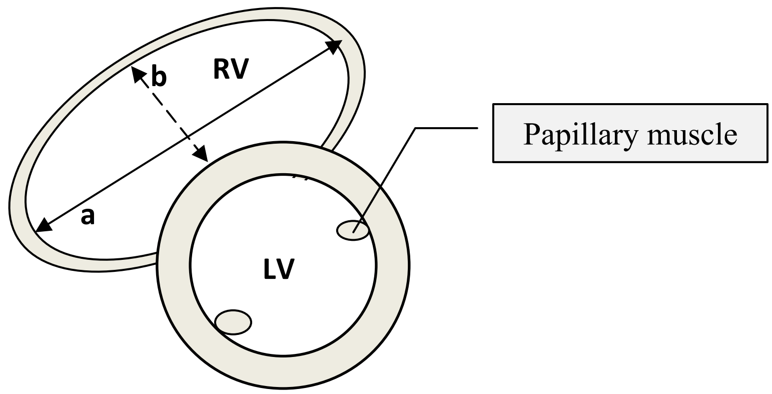

Figure 5. Parasternal short axis view. Line ‘b’ (dotted line) measures distance between ventricular septum and right ventricular free wall at the midpoint of the septum. Line ‘a’ represents the longest the longest right ventricular distance. Eccentricity index was calculated as the ratio of ‘a’ to ‘b’. While calculating the length represented by line a, care was taken to exclude the infundibular area.

b. **Right ventricular spherical index.** Right ventricular spherical index was calculated by dividing systolic right ventricular area by right ventricular long axis dimension.[48]

c. **Right ventricular long axis, mid cavity and basal dimension** were measured from a right ventricle focused apical 4 chamber view at end diastole. **Right ventricular mid cavity dimension:** distance between right ventricular free wall and the septum measured in the middle third of the right ventricle at the level of left ventricular papillary muscles. **Long axis dimension:** distance between tip of the true right ventricular apex and the midpoint of the TV annular plane. Right ventricular basal diameter was defined as the maximal short axis dimension in the basal third of the right ventricle (figure 6).

d. **Right ventricular end-diastolic & end - systolic area** was calculated from the right ventricle focused apical 4 chamber view by planimetry tracing the endocardial outline of the right ventricle and the plane of the TV.

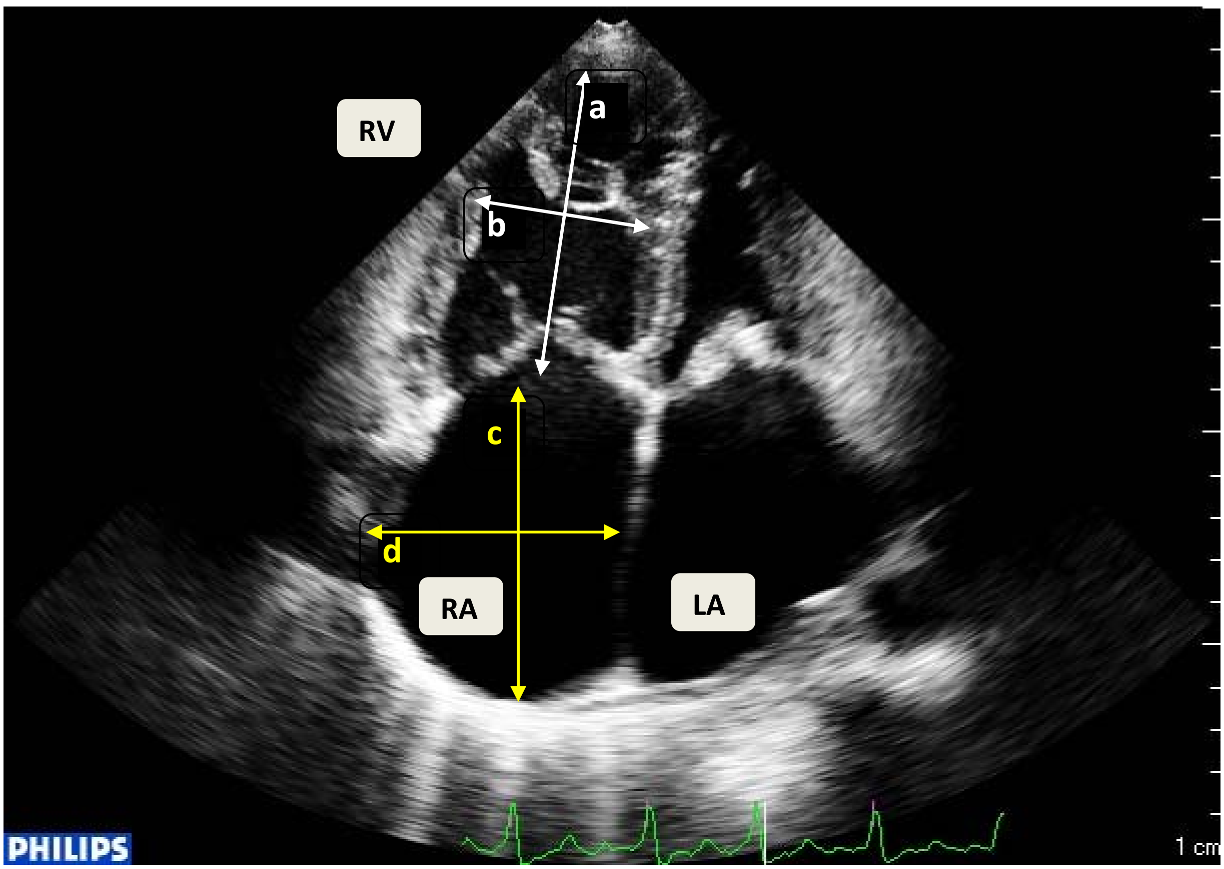

Figure 6. Right atrial and ventricular dimensions. Line a represents right ventricular long axis dimension. Line b represents right ventricular mid cavity dimension. Line c represents right atrial major dimension. Line d represents right atrial minor dimension. RA stands for right atrium and RV stands for right ventricle. LA stands for left atrium.

B. **Right Ventricular Function and Hemodynamic parameters**

a. **Right ventricular fractional area change (FAC)** was calculated as (end diastolic area - end systolic area)/ end diastolic area x 100.

b. **Tricuspid annular plane systolic excursion (TAPSE)** was measured as the amount of longitudinal motion of the annulus at peak systole using an M-mode beam across the lateral annulus.

c. **Right Ventricular Tei index or myocardial performance index** (RV MPI) was measured using color tissue Doppler. RV MPI= (tricuspid valve closure opening time- ejection time)/ ejection time.

d. **Myocardial acceleration during isovolumic contraction (IVA)** was measured using color tissue Doppler. IVA = peak isovolumic myocardial velocity divided by time to peak velocity.

e. **Right ventricular systolic pressure (RVSP) / Systolic pulmonary artery pressure** was estimated from the peak TR jet velocity (V) using Bernoulli equation and adding it to the estimated right atrial pressure. $RVSP = 4 (V)^2 +$ estimated right atrial pressure.

C. **Tricuspid annulus and valve measurements**

a. **End-systolic and end-diastolic TV annulus dimension** was measured from the septal leaflet insertion point to the anterior leaflet point at end systole and end diastole respectively from an apical 4 chamber view. Tricuspid annular contraction was calculated as (End-diastolic TV annulus diameter - End-systolic TV annulus diameter) End-diastolic TV annulus diameter x 100.

b. **Tethering height and area** was measured from the apical four chamber view. Valve tethering area and height was measured by the area and distance enclosed between tricuspid leaflets and the tricuspid annular plane at the time of maximal systolic closure (figure 7).

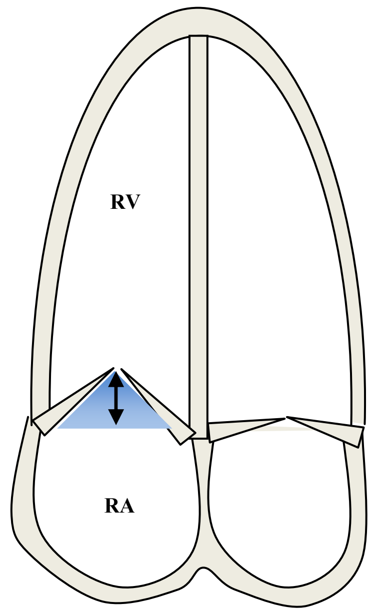

Figure 7. Measurement of tricuspid valve tethering height and area. Shaded area represents tethering area. Arrow line measures the tethering height. RA stands for right atrium and RV stands for right ventricle.

D. Right Atrial Parameters

a. **Estimation of right atrial pressure.** Right atrial pressure was estimated integrating inferior vena cava (IVC) diameter and the presence of inspiratory collapse. Right atrial pressures were calculated as per the recommendations of American Society of Echocardiography (ASE) Guidelines 2010.

Table 6 summarizes the values for Right atrial pressures based on IVC diameter and its collapse with sniff.

Variable	Normal RA pressure 3 mmHg	Intermediate RA pressure 8 mmHg	Intermediate RA pressure 8 mmHg	High RA pressure 15 mmHg
IVC diameter,cm	≤ 2.1	≤ 2.1	> 2.1	>2.1
Collapse with sniff	>50%	< 50%	>50%	< 50%

Table 6. Estimation of right atrial (RA) pressure

b. **End-systolic Right atrial area** was calculated by planimetry from the apical 4 chamber view.

c. **Major dimension** is calculated from apical 4 chamber window as the long axis distance of the right atrium from the center of the plane of TV annulus to the superior right atrial wall.

d. **Minor dimension** is calculated as the distance between the mid-point of right atrial free wall to the inter-atrial septum perpendicular to the long axis.

E. **Left Ventricular parameters**

a. **Left Ventricular ejection fraction** was calculated using Simpson's method from the apical views.

b. **Left ventricular long axis dimension** was obtained from the apical 4 chamber window as the distance between tip of ventricular apex and the midpoint of the mitral valve annular plane.

c. **Left Ventricular spherical index** was obtained by dividing left ventricular end-systolic volume by the left ventricular long axis dimension in the apical 4 chamber window.

F. **Pulmonary artery hypertension** - defined as estimated systolic pulmonary artery pressure (RVSP) more than 50 mmHg, estimated by the method mentioned above (see section on 'Right Ventricular Function and Hemodynamic parameters').

G. Grading of severity of functional TR

a. **Functional TR** was defined as the presence of TR in the absence of organic TV disease or prior TV surgery.

b. **Grading of tricuspid regurgitation.** Functional TR was graded based on the criteria used in the Framingham heart study and by incorporating qualitative and quantitative parameters for severe TR as recommended by various guidelines.[63,67] According to the criteria used by Singh et al[67], TR was classified as mild if jet area/ Right atrial area < 19%, moderate if between 20-40% and severe if >40%. Same criteria was used in another study on TR by Nath et al.[2] Values of quantitative parameters for grading TR as severe were vena contracta width >7 mm and effective regurgitant orifice area, EROA >40 mm^2. EROA was measured using the proximal isovelocity surface area method and was calculated as EROA= 2x Π x [radius of the proximal isovelocity surface (in centimeter)]^2 x aliasing velocity (in centimeter per second) / Peak velocity of the functional TR (in centimeter per second). Vena contracta width was measured at midsystole as the narrowest neck of regurgitation, just distal to flow convergence region.

H. Three dimensional echocardiography measurements

a. **Tricuspid annulus dimension.** TV annulus shape and dimensions were assessed on a short axis image plane. Septal-lateral and antero-posterior longitudinal planes were obtained using method described by Park et al[52] to measure the septal-lateral and antero-posterior annulus diameter

b. **Angles between TV leaflets and the annulus plane**. Three longitudinal planes that perpendicularly crossed the middle of each TV leaflet were obtained and on each of these planes, angles between the annulus plane and the leaflets were measured on a mid systolic frame. They were named as septal, anterior and posterior angle (figure 8a,b,c).

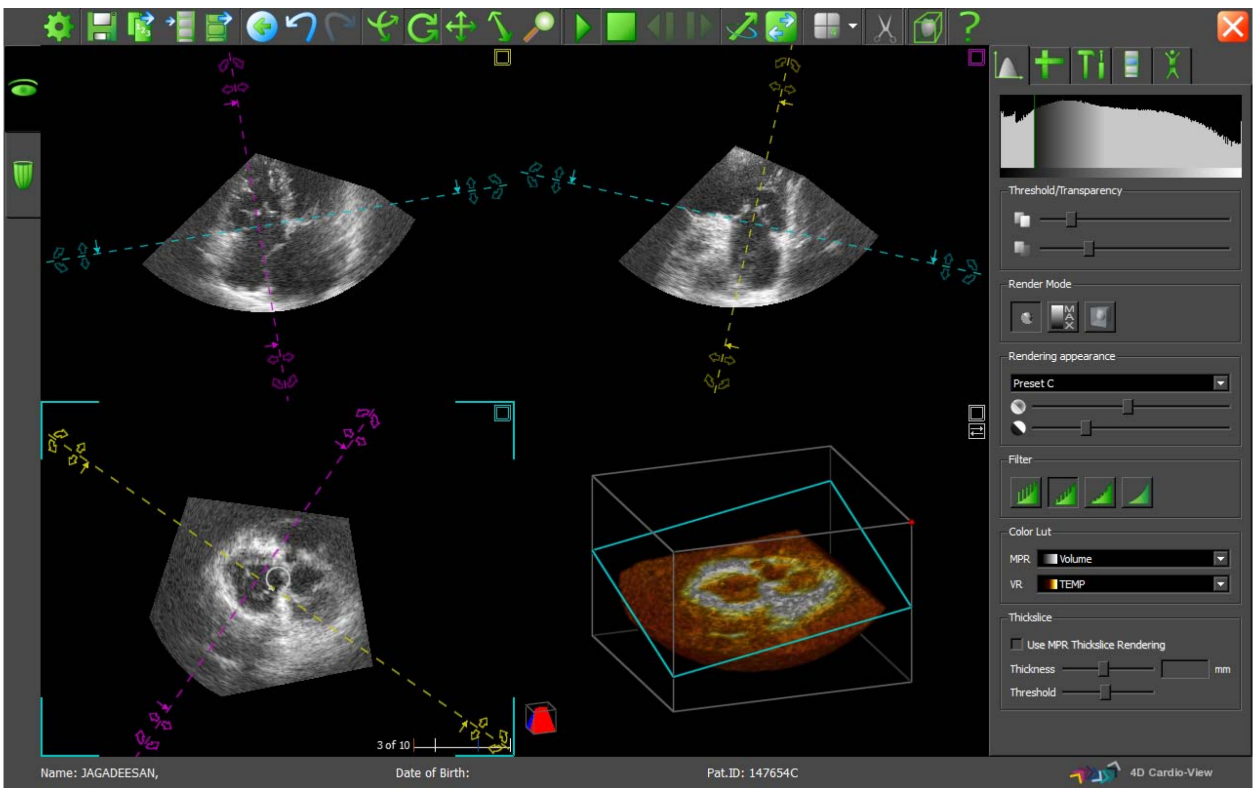

Figure 8a.Measurement of tricuspid annulus and leaflet angles using dedicated software

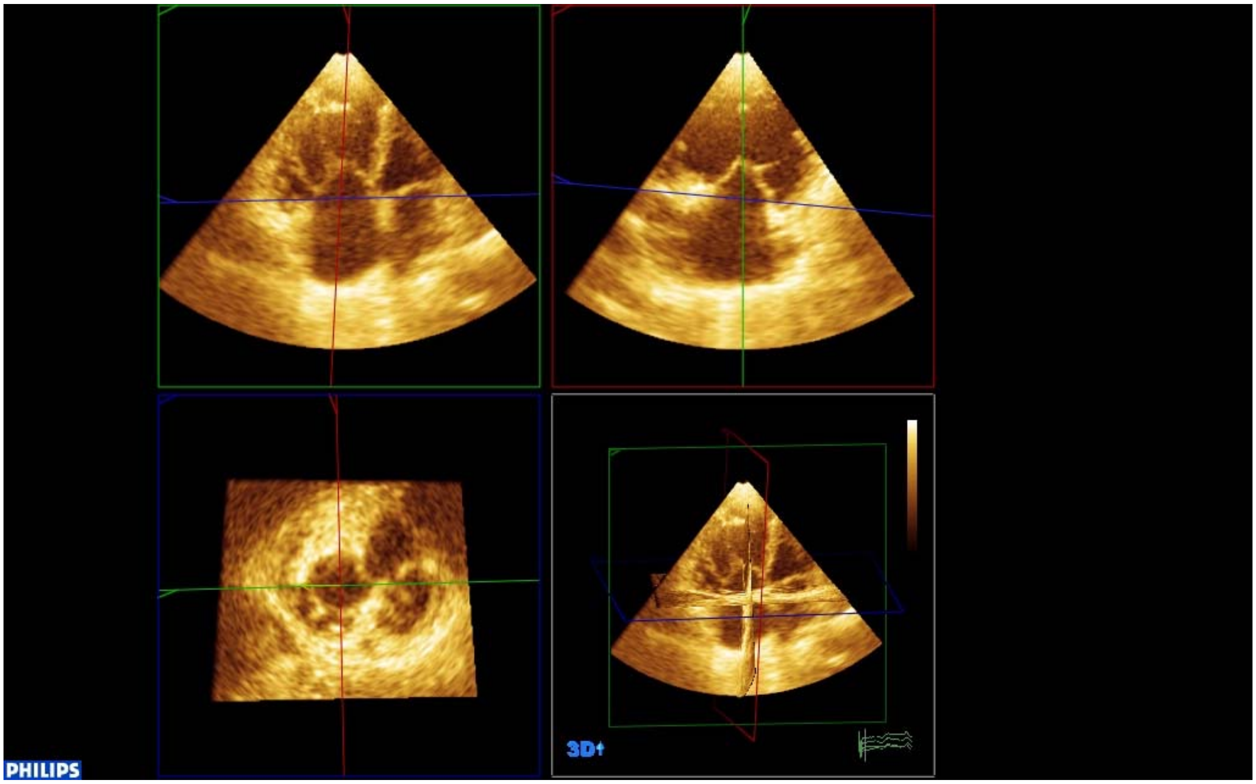

Figure 8b.Measurement of tricuspid annulus and leaflet angles using dedicated software

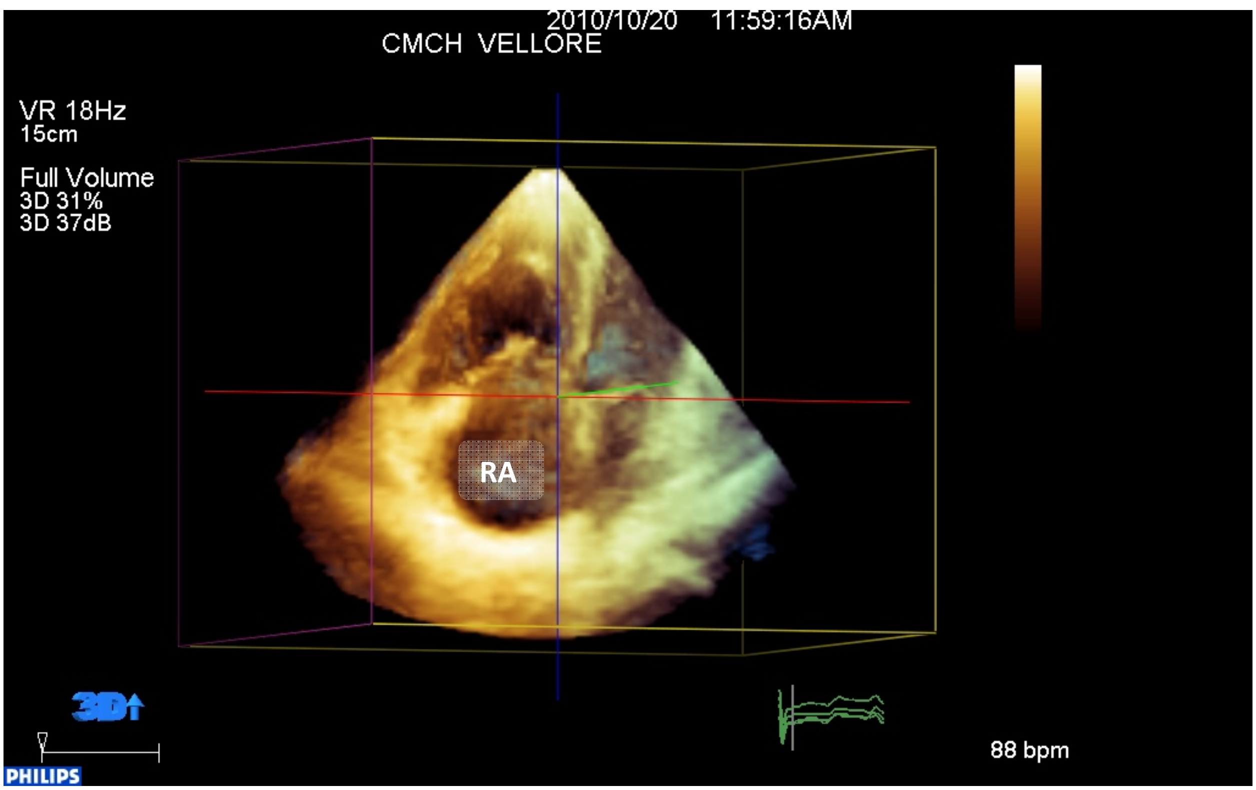

Figure 8c. 3-D imaging of the right heart and the tricuspid valve

SAMPLE SIZE

Sample size was estimated by a- priori sample size calculator for multiple regression using G*Power software, release 3.1.2 (January 2010) and an online software available at *http://www.danielsoper.com/statcalc/calc01.aspx*. The minimum required sample size for study was determined to be 108, given the alpha level - 0.05, number of predictors in the model assumed to be eight, anticipated effect size (f^2) of 0.15 and desired statistical power level of 0.80 (figure 9). It was estimated that a total of 110 patients would be a sufficient sample size for the multiple regression analysis.

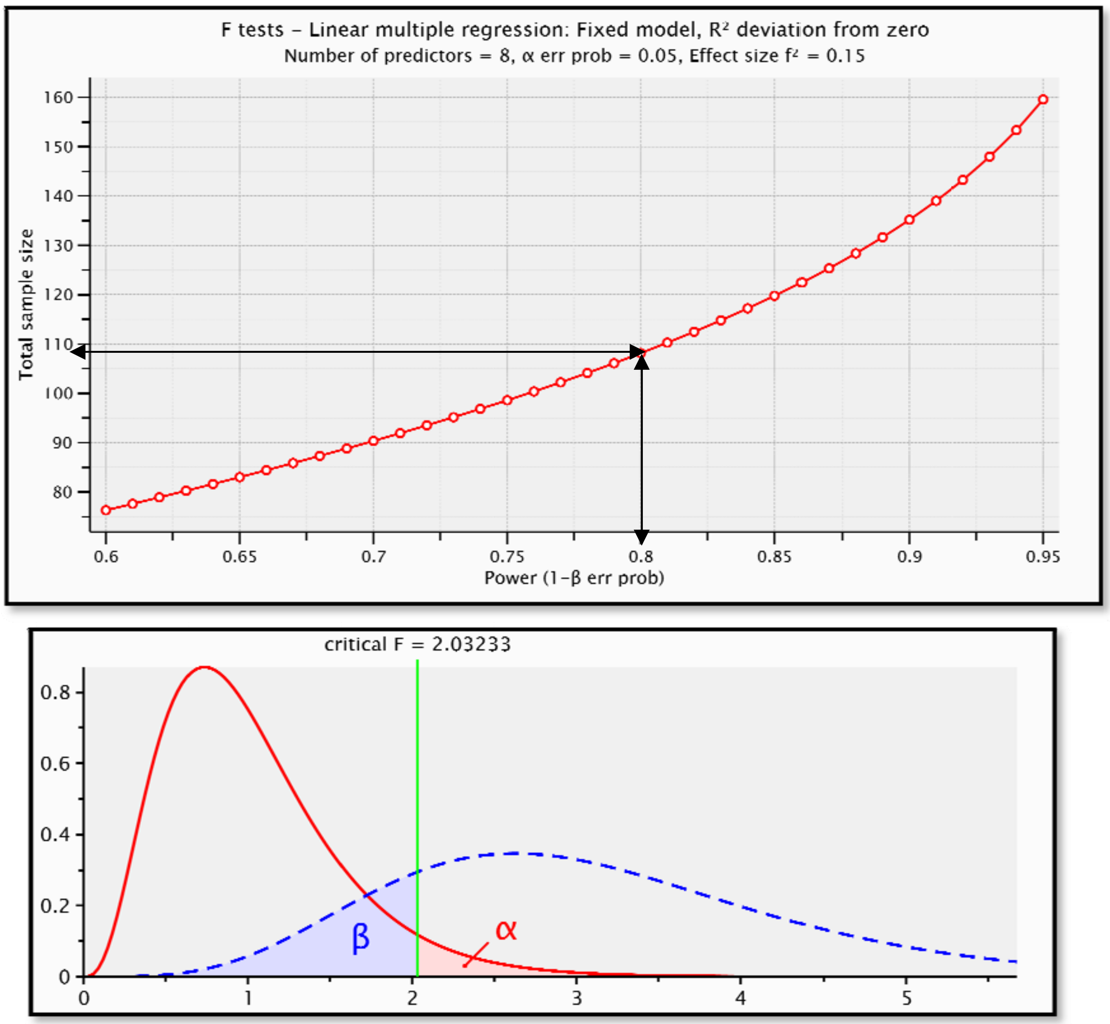

Figure 9. Sample size Calculation. Graph showing the cutoff sample size given alpha level - 0.05, power 0.80.

STATISTICAL ANALYSIS

Commercially available statistical software ('IBM SPSS Statistics software version 18', Illinois, Chicago) was used for data analysis. All continuous variables were expressed as mean ± SD and categorical variables were expressed as number (percentage). Comparative analysis of the three study groups (mild, moderate & severe TR) was performed by one way analysis of variance (ANOVA) with appropriate post hoc tests (Scheffe and Games Howell) for continuous variables with a normal distribution. In brief, Scheffe test was used when assumption of homogeneity of variances was met and Games Howell test used when it was not met. Kruskal-Wallis one way analysis of variance by ranks was used for comparative analysis of continuous variables with a skewed distribution. Independent samples T test was used for comparative analysis of two groups with a normally distributed continuous variables. Mann Whitney U test was used for comparison of continuous variables which were not normally distributed. Comparison of categorical variables was done by Chi square test. Pearson correlation coefficient was used to analyze the correlation between continuous variables with a normal distribution. The echocardiographic parameters which were independently associated with functional TR severity were identified by multiple stepwise linear regression analysis. P value less than 0.05 by univariate analysis was used as the entry cut off for the multivariate analysis. The sensitivity and specificity of various cut-off points that reliably predicted functional TR of more than moderate degree was calculated by plotting receiver-operator characteristic curves. Lin's concordance correlation coefficient (ρ-c) was calculated to assess intra-observer and inter-observer variability. A p value of <0.05 was considered statistically significant for all test results.

Methodology: Statement of Limitations and Ethical Issues

Statement of Limitations

1. Referral bias. The hospital being a tertiary medical center, possibility of referral bias was considered. Since TR prevalence was not the main outcome of the study, any referral bias was not expected to affect the study analysis.

2. Physiologic conditions, settings of the machine and characteristics of the jet can influence methods used to quantify TR severity.

3. At present, there is a lack of standardized measurements and specific software for quantitative assessment of tricuspid annulus and leaflets by 3-dimensional echocardiography.

Ethical Issues

As mentioned earlier, the study was conducted in accordance with the Declaration of Helsinki and within the framework of Good Clinical Practice. The study protocol was presented before the Research and Ethics Committee of this institution. Various ethical issues pertaining to the study were discussed. The study was cleared by the Committee. Informed consent document is attached under annexure.

Key ethical issues

Some of the key ethical issues related to the study are listed below.

1. By participating in this study, there were no added risks involved to the participants.

2. Selection of subjects was fair and there was no discrimination with regard to age, sex, social status, caste or religion while choosing subjects.

3. Steps were taken to maintain confidentiality of the data collected.

4. Scientific validity: Well accepted scientific principles and methods were used to produce reliable data.

5. Copyright permissions were obtained from the author and publisher while reproducing select contents published in medical literature.

RESULTS

I. STUDY PROFILE & BASELINE CHARACTERISTICS

Between May 2010 and December 2010, a total of 174 patients with functional TR were screened for inclusion into the study. Forty six patients were excluded because of echocardiographic window which was suboptimal for a complete quantitative evaluation of the tricuspid valve or the right ventricle. Six patients were excluded because of organic tricuspid valve disease. Three patients had past history of tricuspid annuloplasty and were excluded. Three patients were excluded because of permanent pacemaker implantation. Six patients were excluded because of Ebstein's anomaly of the TV. After exclusions, a total of 110 functional TR patients were included in the study. Figure 10 shows the flow and profile of patients in this study.

Of the total 110 functional TR patients, 33 (30%) had mild TR, 30 (27%) had moderate TR and 47 (42%) had severe TR. Twenty one patients formed controls which were used for comparison of baseline parameters and to obtain an estimate of the normal values for various echocardiographic parameters such as tricuspid annulus dimension, tethering area, tethering distance, and right ventricular spherical and eccentricity index. Table 7 shows the various echocardiographic and clinical parameters of the entire study population. Mean age of the functional TR patients was 42 ± 15 years. Fifty nine percent of them were females. The mean body surface area was 1.45 ± 0.17 sq cm. Forty percent of the functional TR group had atrial fibrillation. Mean heart rate was 88 ± 19 beats per minute and was comparable to that of the controls. Majority of the patients were in NYHA class II.

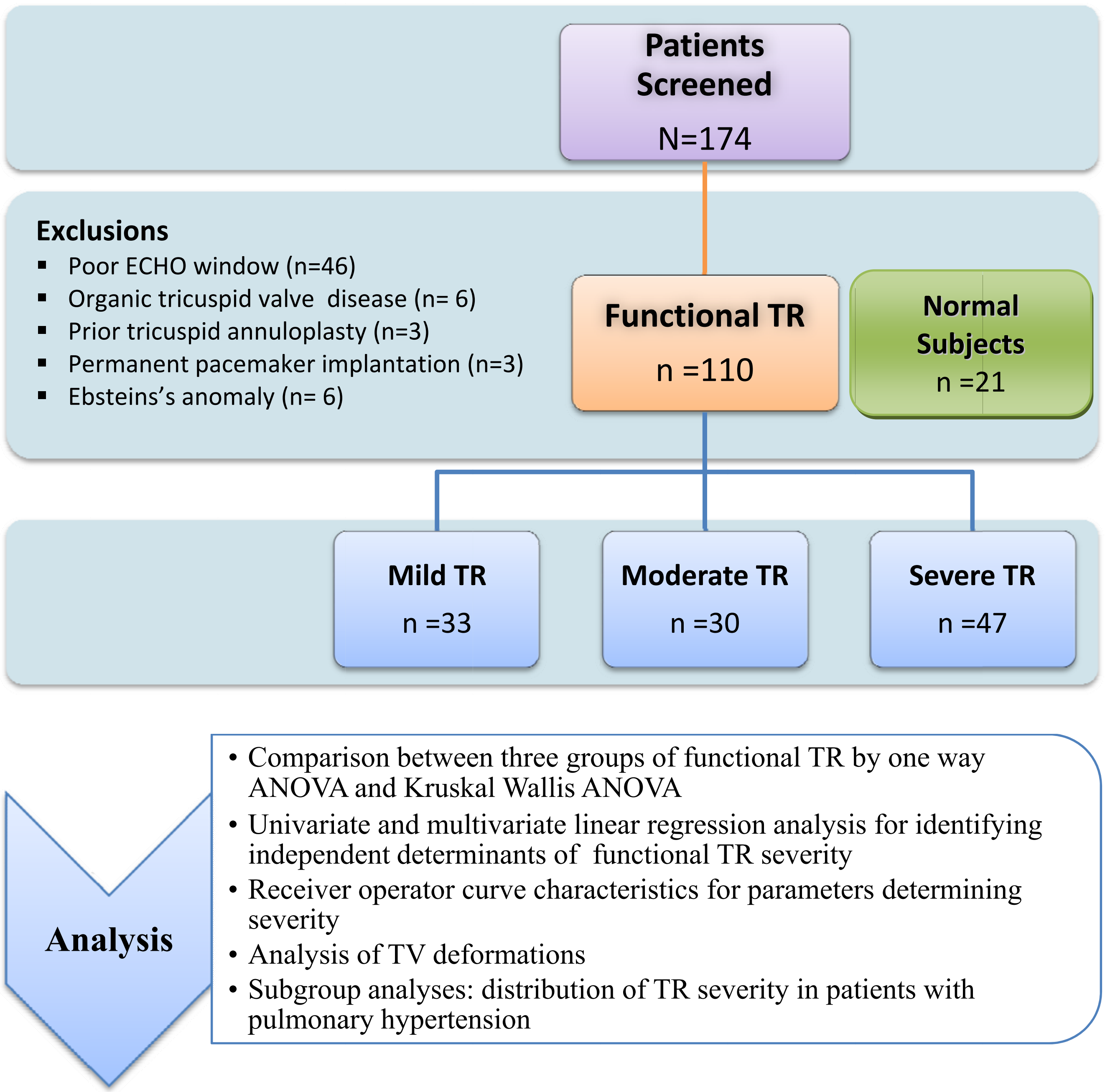

Figure 10. Study flow chart

	Functional TR n=110	Controls n =21	*p*
Age, years	42 ± 15	48 ± 13	0.053
Females, n (%)	65 (59)	9 (43)	0.169
Height, cm	156 ± 9	159 ± 10	0.302
Weight, kg	49 ± 10	57 ± 9	0.001
BSA, m^2	1.45 ± 0.17	1.57 ± 0.16	0.003
Rhythm Sinus, n Atrial Fibrillation, n	66 44	21 -	 -
NYHA Class (n) I II III	5 101 4	-	-
Heart rate (beats per minute)	88 ± 19	83 ± 9	0.215
Left ventricle • End diastolic volume, ml • End systolic volume, ml • Ejection fraction,% • Spherical index	 100.9 ± 52.8 47 ± 33 55 ± 9 6.85 ± 4.4	 87.7 ± 15.6 36.4 ± 6.6 59 ± 2 5.28 ± 1.0	 0.259 0.131 0.086 0.295
Right Ventricle • Mid dimension, cm • Basal dimension, cm • Long axis dimension, cm • Eccentricity index: End systolic : End diastolic • Spherical index • Fractional area change,% • Tei index(MPI)	 3.4 ± 0.8 4.5 ± 0.9 6.6 ± 0.9 2.11 ± 0.22 2.14 ± 0.25 2.05 ± 0.75 38.3 ± 7.7 0.59 ± 0.14	 2.3 ± 0.2 3.1 ± 0.3 6.1 ± 0.4 1.91 ± 0.13 1.89 ± 0.12 1.35 ± 0.22 41.2 ± 6.9 0.52 ± 0.03	 < 0.001 < 0.001 0.005 < 0.001 < 0.001 < 0.001 0.088 0.016
Right atrium • Major dimension, cm • Minor dimension, cm • End systolic area, cm^2	 5.5 ± 1.2 4.3 ± 1.1 21.91 ± 8.56	 3.6 ± 0.3 3.2 ± 0.4 10.98 ± 2.10	 < 0.001 < 0.001 < 0.001
Tricuspid Annulus • End diastolic diameter, cm • Indexed End diastolic diameter, cm/m^2 • End systolic diameter, cm • Indexed End systolic diameter, cm/m^2 • Annulus contraction %	 3.53± 0.67 2.46 ± 0.52 3.01 ± 0.62 2.09 ± 0.47 15 ± 4	 2.59 ± 0.19 1.65 ± 0.19 2.25 ± 0.17 1.44 ± 0.16 13 ± 3	 < 0.001 < 0.001 < 0.001 < 0.001 0.066
Tricuspid valve tethering height, cm	0.81 ± 0.37	0.18 ± 0.04	< 0.001
Isovolumic acceleration, m/s^2	3.14 ± 1.18	4.46 ± 1.42	< 0.001
Tricuspid annular plane systolic excursion, cm	1.93 ± 0.39	2.25 ± 0.17	< 0.001

Table 7. Echocardiographic and clinical characteristics of the entire study population.

Patients and controls were comparable for various indices of left ventricular function and geometry. There were no significant differences between the two groups for age, sex, height, heart rate or the right ventricular FAC. The functional TR patients had significantly lower weight and body surface area compared to normal subjects. Significant differences between the functional TR and normal subjects were observed for various indices of right ventricular function and geometry, tricuspid annulus and right atrial measurements. Mean tricuspid annulus dimension (end diastolic) was 3.52 ± 0.67 cm in the functional TR group and 2.59 ± 0.19 cm in normal subjects group. We also recorded TAPSE, right ventricular myocardial performance index and isovolumic acceleration, values of which were significantly different between the groups.

Based on the criteria mentioned earlier under methodology, functional TR patients were classified into three groups- mild, moderate and severe. Mean values with standard deviations of various quantitative parameters of tricuspid regurgitation severity are presented in table 8. The mean values of vena contracta and effective regurgitant orifice area of patients belonging to severe functional TR group were 8.1 mm and 46.1 mm^2 respectively.

	Mild TR (n=33)	**Moderate TR (n=30)**	**Severe TR (n=47)**
Vena Contracta (mm)	2.6 ± 0.6	5.6 ± 0.8	8.1 ± 1.8
Effective Regurgitant Orifice area (mm^2)	7.3 ± 3.6	15.8 ± 6.2	46.1 ± 7.5
Trans tricuspid E wave velocity (cm/sec)	67.8 ± 15.2	77.8 ± 15	104.6 ± 22

Table.8 Echocardiographic parameters of tricuspid regurgitation severity

Clinical Characteristics of the patients belonging to the three groups of severity of functional TR are presented in table 9.

Variable	Mild TR (n=33)	Moderate TR (n=30)	Severe TR (n=47)	*p*
Atrial Fibrillation	5 (15)	13 (43)	26 (55)	0.001
Systolic Murmur	4 (9)	5 (17)	37 (79)	< 0.001
'V' waves JVP	0 (0)	4 (13)	36 (77)	< 0.001
Ascites	0 (0)	1 (3)	5 (10)	0.121
Pedal Oedema	0 (0)	1 (3)	5 (10)	0.121
Pulsatile liver	0 (0)	1 (3)	17 (36)	< 0.001
'See- saw' chest movement	1 (3)	11 (37)	36 (77)	< 0.001
NYHA				
I	4 (12)	1 (3)	0 (0)	
II	29 (88)	29 (97)	43 (91)	
III	0 (0)	0 (0)	4 (9)	0.013
Diuretics	26 (79)	25 (83)	43 (91)	0.247
Digoxin	16 (48)	20 (67)	37 (79)	0.019
Betablockers	14 (42)	11 (37)	13 (28)	0.377
ACE inhibitors	7 (21)	6 (20)	9 (19)	0.975
Angiotensin II receptor blocker	2 (6)	1 (3)	1 (2)	0.815
Calcium channel blockers	5 (15)	10 (33)	15 (32)	0.173

Table 9. Clinical Characteristics of the study population. Values are expressed as number (percentage). ACE, angiotensin converting enzyme.

II. ETIOLOGY OF FUNCTIONAL TR

Spectrum of clinical diagnosis in patients with functional TR in this study is summarized in the table given below (see table 10). Rheumatic valvular heart disease especially involving mitral valve was by far the most common clinical condition present in patients with functional TR. Seventy percent of cases had rheumatic valvular heart disease. Other causes for functional TR in this study included dilated cardiomyopathy, ischemic cardiomyopathy, primary pulmonary hypertension, Cor pulmonale, chronic liver disease and non rheumatic left side valvular heart disease (figure 11).

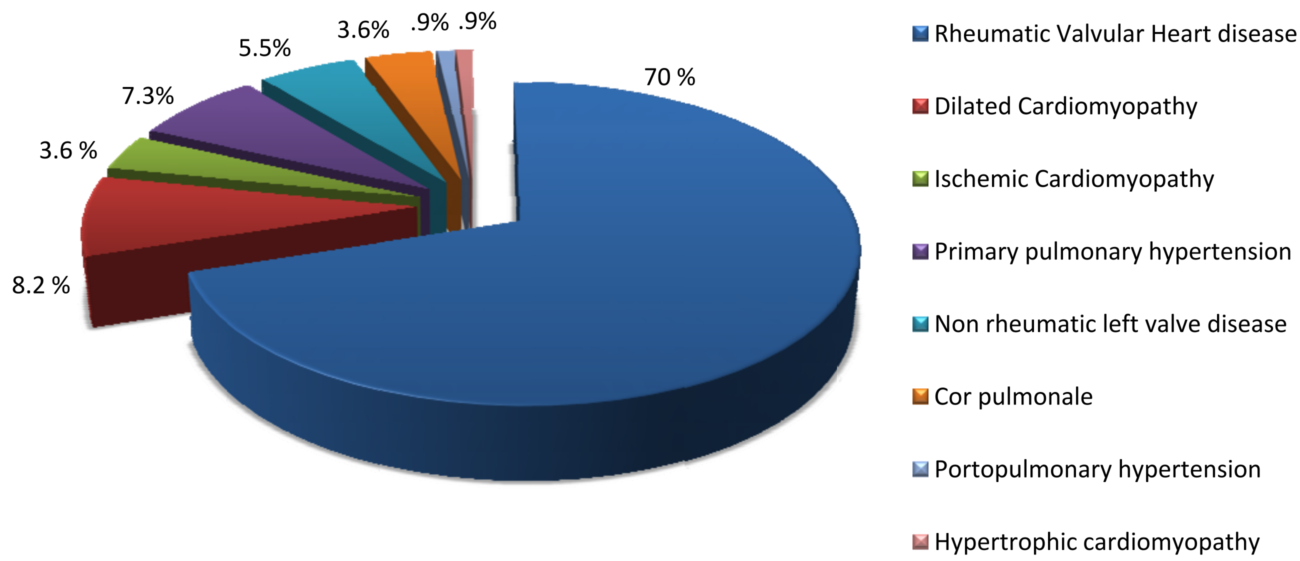

Figure 11. Clinical diagnosis in functional TR patients.

Etiology	**Number (percentage)**
Rheumatic Heart Disease	77(70)
Dilated cardiomyopathy	9 (8.2)
Primary pulmonary hypertension	8 (7.3)
Non rheumatic left side valve disease	6 (5.5)
Ischemic cardiomyopathy	4 (3.6)
Cor Pulmonale	4 (3.6)
Chronic liver disease with portopulmonary hypertension	1 (0.9)
Hypertrophic cardiomyopathy	1 (0.9)

Table 10. Clinical diagnosis in functional TR patients.

III. MECHANISMS AND DETERMINANTS OF FUNCTIONAL TR SEVERITY

A. Comparison of clinical and echocardiographic parameters between the three groups of functional TR

The clinical and echocardiographic measurements of the three study groups of functional TR are presented in Table 11. Comparative analyses across the three groups were done by ANOVA with post hoc tests for continuous variables and chi-square tests for categorical variables. There were no significant differences between the groups with regard to age, gender, left ventricular volumes, left ventricular ejection fraction, left ventricular spherical index and tricuspid annulus contraction.

Severe functional TR group had significantly more number of subjects with atrial fibrillation. There was a statistically significant trend for right ventricular end-systolic and end-diastolic eccentricity index, tricuspid annulus dimension (end-diastolic and end-systolic), tricuspid valve tethering height and area, and end systolic right atrial area to increase as functional TR increased from mild to severe (p value for linear trend < 0.001) (figure 12). Severe functional TR group had significantly greater right ventricular dimensions when compared with the other two groups ($p < 0.001$). Estimated Pulmonary artery systolic pressure was also significantly higher in the severe group as compared to the other groups. This could be due to the predominant rheumatic etiology. Moderate and severe groups had significantly lower right ventricular FAC as compared to the mild functional TR group.

	Mild (n=33)	Moderate (n=30)	Severe (n= 47)	*p*	P value trend
Age, years	39 ± 17	41 ± 14	43 ± 13	0.403	-
Men, n (%)	14	11	20	0.858	-
Atrial Fibrillation, n (%)	5	13	26	**0.001**	**-**
Left Ventricle					-
• End diastolic volume, ml	87.7 (71.7 -107.8)	97.7 (81.8 - 122.5)	83.1(62.7 - 111)	0.099	
• End Systolic volume, ml	36 (29.8 - 47.4)	41.4 (33 - 72.3)	32.6 (25.8 - 54.1)	0.436	
• Ejection Fraction, %	55.7 ± 8.9	55.2 ± 9	54.6 ± 9.1	0.872	
Left Ventricular spherical index	6.58 ± 4.09	7.79 ± 4.81	6.43 ± 4.38	0.390	-
Right Ventricle					
• Basal dimension, cm	3.9 ± 0.6	4.08 ± 0.6	5.2 ± 0.8*	**<0.001**	**-**
• Mid dimension, cm	2.8 ± 0.5	3.1 ± 0.7	3.9 ± 0.7*		
• Longitudinal dimension, cm	6.2 ± 0.7	6.4 ± 0.8	6.9 ± 0.8*		
Right Ventricular spherical index	1.58 ± 0.33	1.80 ± 0.41	2.53 ± 0.85*	**< 0.001**	**-**
Right Ventricle					
• End systolic EI#	1.90 ± 0.15	2.08 ± 0.10 §	2.28 ± 0.20*	**<0.001**	< 0.001
• End diastolic EI#	1.97 ± 0.15	2.11 ± 0.18 §	2.29 ± 0.26*		
Estimated Pulmonary artery systolic pressure, mmHg	43 ± 15	53 ± 19	70 ± 27 §□	**< 0.001**	**-**
Tricuspid Valve					
• Tethering area, cm^2	0.74 ± 0.27	1.16 ± 0.43 §	2.30 ± 0.70*	**<0.001**	< 0.001
• Tethering Height, cm	0.45 ± 0.14	0.69 ± 0.18 §	1.14 ± 0.26*		
Tricuspid Annulus					
• End systolic dimension, cm	2.41 ± 0.29	2.79 ± 0.26 §	3.57 ± 0.44*	**<0.001**	< 0.001
Indexed end systolic dimension, cm/m^2	1.70 ± 0.27	1.93 ± 0.22□	2.48 ± 0.39*	"	-
• End diastolic dimension cm	2.85 ± 0.31	3.27± 0.28 §	4.17 ± 0.39*	**<0.001**	< 0.001
Indexed end diastolic dimension, cm/m^2	2.01 ±0.31	2.26 ± 0.26□	2.90± 0.39*	"	-
• Annulus Contraction, %	15 ± 5	15 ± 4	15 ± 4	**0.514**	
Right Atrial End systolic area, cm^2	15.01 ± 3.26	19.35± 3.06 §	28.38 ± 8.88*	**< 0.001**	< 0.001
Right Ventricular Fractional area change, %	42.3 ± 5.7	38.2 ± 6.4 §	35 .6 ± 8.5 §	**< 0.001**	**-**
TAPSE	2.16 ± 0.28	1.96 ± 0.31□	1.73 ± 0.41§□	**< 0.001**	**-**
Right Ventricular MPI	0.54 ± 0.09	0.59 ± 0.14	0.62 ± 0.15□	**0.023**	-
Isovolumic acceleration	3.4 ± 1.2	3.6 ± 1.0	2.6 ± 1.1□□	**< 0.001**	-

Table 11. Comparison of various clinical and echocardiographic parameters of three groups of functional TR.

*p < 0.001 versus mild & moderate group

§p < 0.001 versus mild group

□p < 0.05 versus mild group

□p <0.05 versus moderate group

□p <0.005 versus moderate group

#EI- Eccentricity index.

Analysis was done using ANOVA except for left ventricular volumes where Kruskal Wallis test used. Left ventricular volumes are expressed as median (interquartile range).

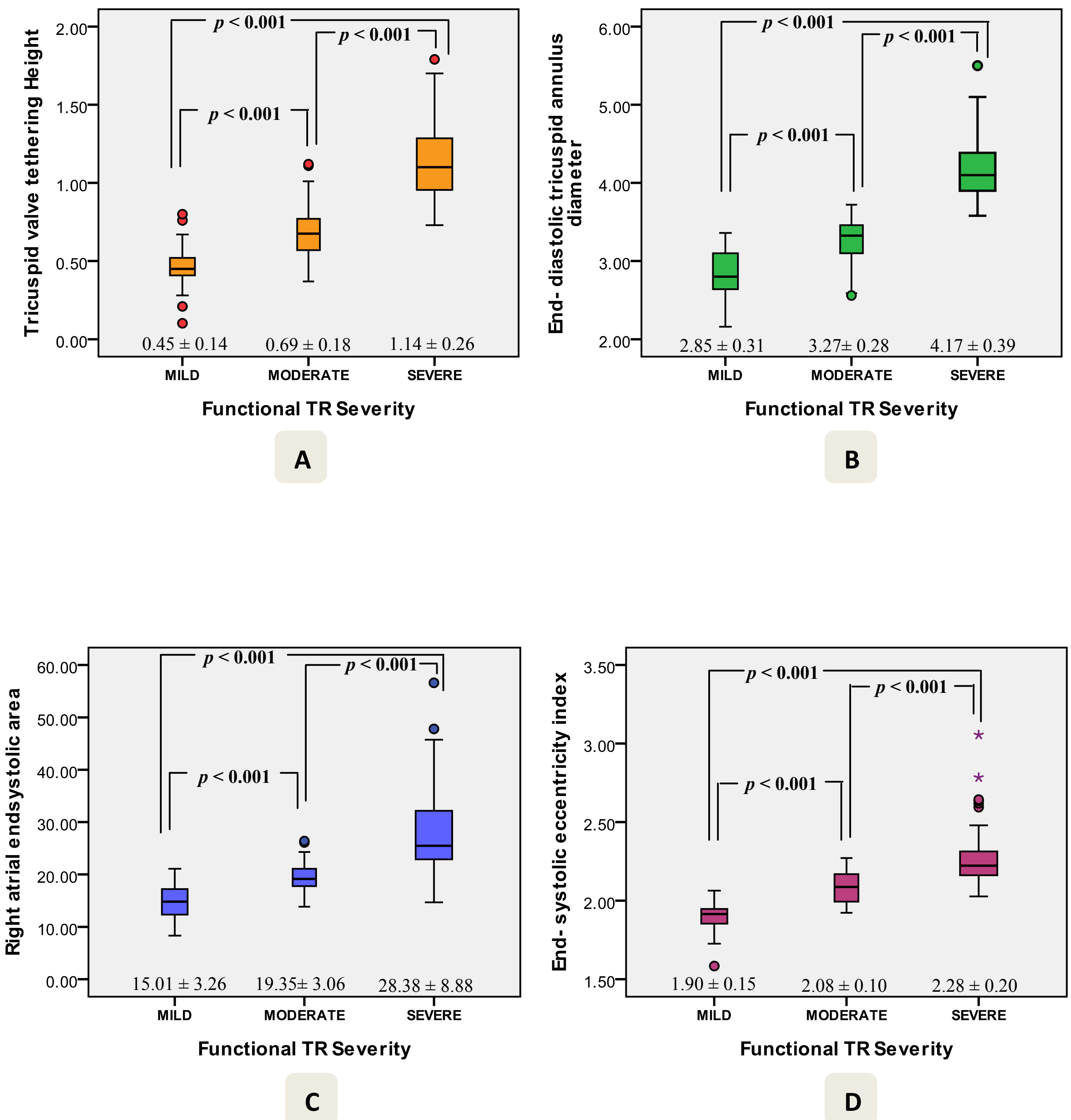

Figure 12. Comparison of tricuspid valve tethering height (A), end diastolic tricuspid annulus diameter (B), Right atrial end-systolic area (C) and right ventricular end - systolic EI (D) across the three groups of Functional TR.

B. Independent determinants of functional TR severity

After considering plausibility, select echocardiographic parameters were tested for significant correlation with effective regurgitant orifice area treated as a continuous variable. Several measurements of right ventricular and tricuspid annulus geometry, right atrial size, right ventricular function and estimated pulmonary artery systolic pressure were observed to show significant correlations with the effective regurgitant orifice area by univariate analysis (table 12). Tricuspid annulus contraction percent and other indices of left ventricular function or geometry did not correlate significantly with the effective regurgitant orifice area.

Among the variables shown to have significant correlation with the regurgitant orifice area, tricuspid annulus dimension (end-diastolic and end-systolic), tricuspid valve tethering height and area showed the strongest correlation ($r = 0.864$, 0.834, 0.816 and 0.806 respectively, $p < 0.001$). Scatter plots shown in figure 13 show the relationship between effective regurgitant orifice area and some of these parameters.

Using the aforementioned significant variables by univariate analysis, a multivariate stepwise linear regression analysis was done to identify independent determinants of functional TR severity. TV tethering distance, end-diastolic tricuspid annulus dimension, end-systolic eccentricity index and end-systolic right atrial area were found to independently determine effective regurgitant orifice area and thus severity. Same variables were also found to independently determine severity when relative size of the tricuspid regurgitation jet to the right atrial area was taken as measure of severity.

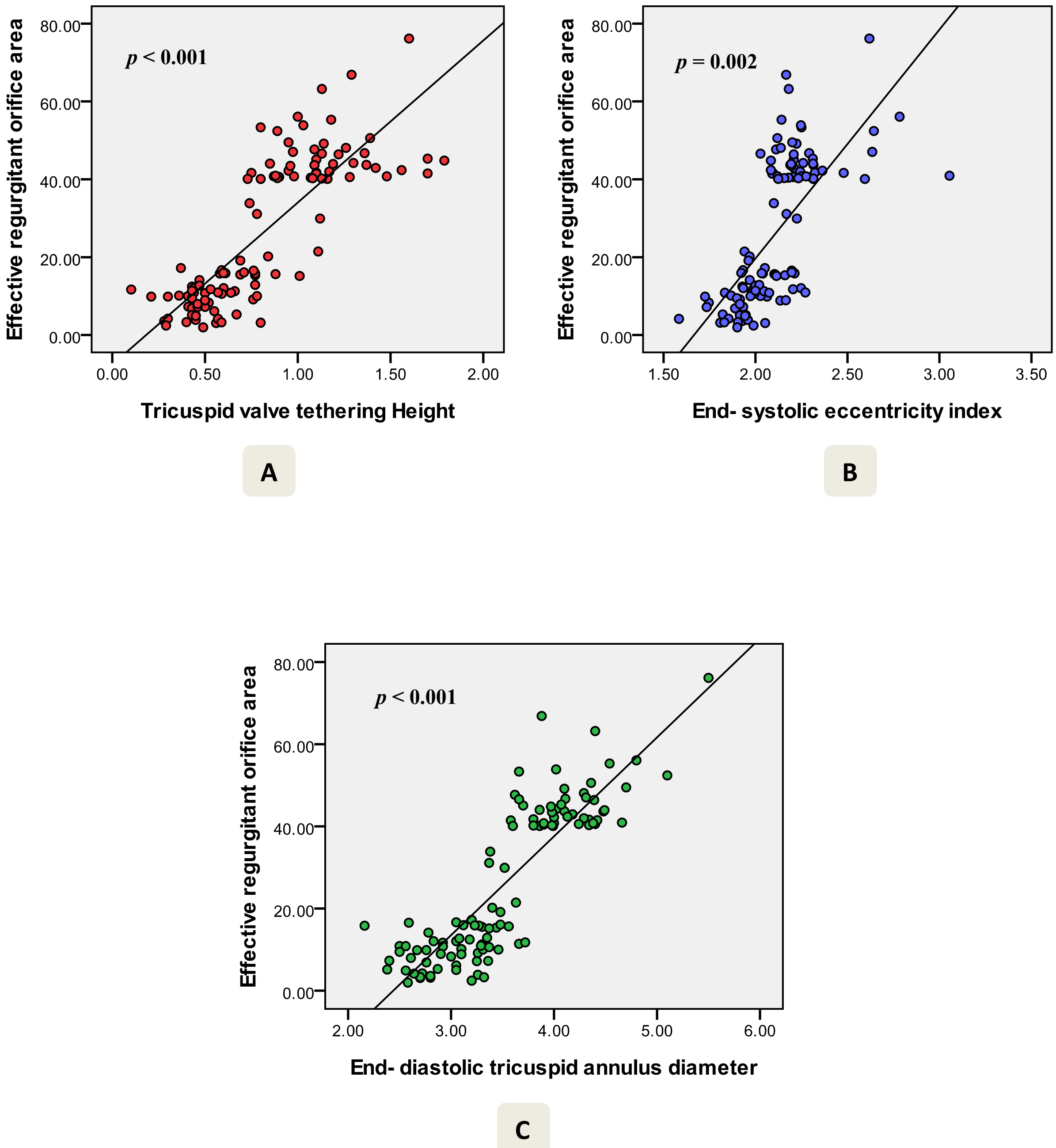

Figure 13. Scatter plot showing correlations of effective regurgitant orifice area with tricuspid valve tethering height (A), right ventricular end systolic EI (B) and end-diastolic tricuspid annulus diameter (C).

Variable	r	Univariate *p*	Multivariate *p*	Standardized coefficient β
Right Ventricular Basal Dimension	0.665	< 0.001	0.630	**-**
Right Ventricular Mid Dimension	0.582	< 0.001	0.968	**-**
Right Ventricular longitudinal Dimension	0.415	< 0.001	0.902	**-**
Right Ventricular end-diastolic area	0.605	< 0.001	0.878	**-**
Right Ventricular end-systolic area	0.556	< 0.001	0.823	**-**
Right Ventricular FAC	0.280	0.003	0.609	**-**
Right Ventricular Tei index	0.197	0.039	0.301	**-**
Tricuspid valve tethering area	0.806	< 0.001	0.874	**-**
Tricuspid valve tethering height	0.816	< 0.001	**< 0.001**	**0.406**
Tricuspid annulus dimension, end systolic	0.834	< 0.001	0.967	-
Tricuspid annulus dimension, end diastolic	0.864	< 0.001	**0.001**	**0.313**
Right atrial end-systolic area	0.700	< 0.001	**0.028**	**0.135**
Pulmonary Artery systolic pressure	0.363	< 0.001	0.686	-
Right Ventricular Spherical index	0.536	< 0.001	0.746	-
Right Ventricular End systolic EI#	0.695	0.002	**0.001**	**0.197**
Right Ventricular End diastolic EI#	0.519	< 0.001	0.894	**-**

Table 12. Univariate and multivariate analysis. Relationship of various echocardiographic measurements with effective regurgitant orifice area. (Adjusted $\mathbf{R}^2$ for the model- 0.827)
#EI- Eccentricity index.

C. Receiver-operator characteristic (ROC) curves for parameters predicting severity

ROC curves were used to examine the sensitivities and specificities of various cut off points of parameters that predicted more than moderate functional TR (figure 14). Table 13 summarizes the cut off values, their sensitivities, specificities and calculated positive likelihood ratio. Tricuspid annulus end diastolic diameter value of more than 3.59 cm had a sensitivity and specificity of 98% and 95% respectively in predicting more than moderate functional TR.

Variable	Cut Off Value	Sensitivity	Specificity	Positive likelihood ratio
Tethering height, cm	> 0.79	96	91	10.1
End diastolic tricuspid annulus diameter, cm	> 3.59	98	95	20.4
Indexed Tricuspid annulus end-diastolic dimension, cm/m^2	> 2.40	96	81	5.03
Right Ventricular End systolic EI#	> 2.08	98	76	4.11
Right Atrial end systolic area, cm^2	> 20.41	85	83	4.86

Table 13. Cut off values of predictor variables with their sensitivities and specificities.
#EI- Eccentricity index.

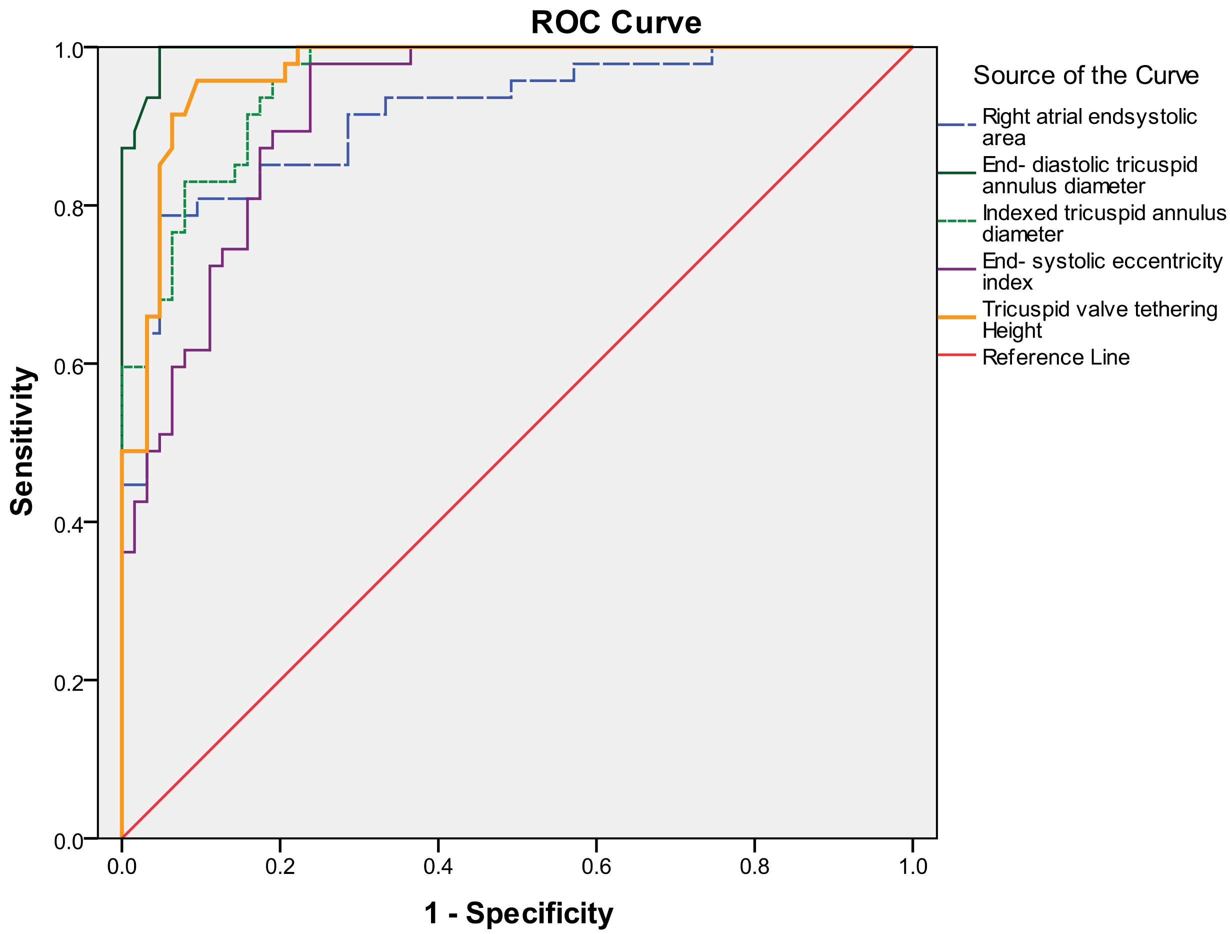

Figure14. Receiver-operator characteristic (ROC) curves of tethering height, tricuspid annulus dimension, right ventricular end systolic EI and end systolic right atrial end systolic area

Variable	Area Under ROC Curve	*p*	*95 % CI*
Tethering height	0.969	< 0.001	0.94 - 0.99
End diastolic tricuspid annulus diameter	0.996	< 0.001	0.00 – 1.00
Indexed Tricuspid annulus end-diastolic dimension	0.956	< 0.001	0.92 - 0.99
Right Ventricular end systolic EI#	0.921	< 0.001	0.87 - 0.97
Right atrial end-systolic area	0.914	< 0.001	0.86 - 0.97

Table 14. Area under ROC curves, 95% confidence intervals. #EI- Eccentricity index.

D. Determinants of tricuspid valve tethering distance and end diastolic tricuspid annulus dimension

Significant correlation was found between end diastolic tricuspid annulus and tethering distance as shown in figure 15.

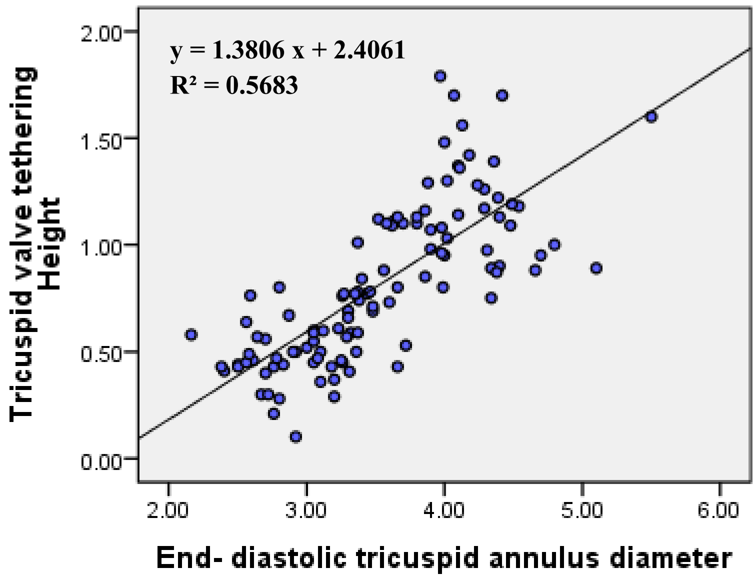

Figure 15. Scatter plot showing correlation of tricuspid valve tethering height with the end diastolic tricuspid annulus dimension.

Factors that determined tricuspid valve tethering distance and end diastolic tricuspid annulus dimension independent of each other were examined. Tethering distance correlated with several right sided chambers indices and estimated pulmonary artery systolic pressure. When all the significant variables by univariate analysis were included in a stepwise linear regression model, right ventricular end-diastolic area ($p < 0.001$), right atrial end-systolic area ($p= 0.040$) and right ventricular end systolic eccentricity index ($p =0.002$) determined tethering height (table 15a).

Similarly, several indices of right ventricular geometry and function correlated with end-diastolic tricuspid annulus dimension. Right ventricular basal dimension ($p < 0.001$), right atrial end-systolic area (p < 0.001), and right ventricular end systolic eccentricity index (p < 0.001), were identified as independent factors that correlated with end- diastolic tricuspid annulus dimension when analyzed by stepwise linear multivariate regression (table 15b).

Variable	r	Univariate *p*	Multivariate *p*
Right Ventricular Basal dimension	0.680	< 0.001	0.250
Right Ventricular long- axis dimension	0.492	< 0.001	0.504
Right Ventricular FAC	0.341	< 0.001	0.800
Right Ventricular end-diastolic area	0.685	< 0.001	**< 0.001**
Right Ventricular end-systolic area	0.642	< 0.001	0.079
Right Ventricular Mid dimension	0.657	< 0.001	0.308
Right atrial end-systolic area	0.567	< 0.001	**0.040**
Estimated Pulmonary artery systolic pressure	0.424	< 0.001	0.771
Right Ventricular Spherical index	0.612	< 0.001	0.206
Right Ventricular End systolic EI#	0.494	< 0.001	**0.002**
Right Ventricular End diastolic EI#	0.342	< 0.001	0.321

Table 15a. Determinants of tricuspid valve tethering height. #EI- Eccentricity index.

Variable	r	Univariate *p*	Multivariate *p*
Right Ventricular Basal dimension	0.688	< 0.001	**< 0.001**
Right Ventricular long- axis dimension	0.420	< 0.001	0.126
Right Ventricular FAC	0.218	0.022	0.897
Right Ventricular end-diastolic area	0.601	< 0.001	0.295
Right Ventricular end-systolic area	0.536	< 0.001	0.406
Right Ventricular Mid dimension	0.568	< 0.001	0.343
Right atrial end-systolic area	0.750	< 0.001	**< 0.001**
Estimated Pulmonary artery systolic pressure	0.285	0.003	0.837
Right Ventricular Spherical index	0.511	< 0.001	0.491
Right Ventricular End systolic EI#	0.730	< 0.001	**< 0.001**
Right Ventricular End diastolic EI#	0.550	< 0.001	0.321

Table 15b. Determinants of end-diastolic tricuspid annulus dimension. #EI- Eccentricity index.

Results of the 3-Dimensional echocardiographic assessment of the tricuspid valve

Quantitative analysis of the 3D data revealed that functional TR group had a significantly larger tricuspid annulus area, circumference, septal-lateral and anteroposterior dimension (table 16a). Severe functional TR group had a larger annulus area and a longer circumference when compared with the other two groups (table 16b). Severe functional TR group also had significantly greater septal-lateral and antero-posterior tricuspid annulus dimension. With increasing severity of TR, annulus was found to assume a circular shape with greater increase in the antero-posterior annulus dimension. Degree of tethering was found to correlate with functional TR severity in all three leaflets (figure 16). Angle between septal leaflet and tricuspid annulus plane correlated best with tethering height and effective regurgitant orifice area (table 17).

Variable	**Control**	**Functional TR**	***p***
Tricuspid annulus area, cm^2	7.2 ± 0.9	10.3 ± 3.6	< 0.001
Tricuspid annulus Perimeter cm	9.1 ± 2.1	11.1 ± 2.1	< 0.001
Septal-lateral diameter, cm	2.95 ± 0.22	3.57 ± 0.58	< 0.001
Anteroposterior diameter, cm	2.60 ± 0.17	3.60 ± 0.69	< 0.001

Table 16a. Comparison of 3-D echocardiographic parameters

Variable	**MILD TR**	**MODERATE TR**	**SEVERE TR**	***p***
Septal angle	19.8 ± 6.2°	26.0 ± 5.6°	39.5 ± 6.1°	< 0.001
Anterior Angle	14.7 ± 5.2°	20.6 ± 5.6°	31.9 ± 6.0°	< 0.001
Posterior Angle	16.6 ± 4.8°	22.7 ± 5.7°	33.9 ± 5.2°	< 0.001
Tricuspid annulus area, cm^2	7.1 ± 1.2	8.6 ± 1.2	13.7 ± 2.7	< 0.001
Tricuspid annulus Perimeter cm	9.4 ± 0.8	10.4 ± 0.7	13.4 ± 1.3	< 0.001
Septal-lateral diameter, cm	3.12 ± 0.24	3.19 ± 0.23	4.13± 0.40	< 0.001
Anteroposterior diameter, cm	2.82 ± 0.24	3.43 ± 0.24	4.27 ± 0.39	< 0.001
Ratio of annulus diameters*	1.11	1.08	1.03	-

Table 16b. Comparison of 3-D echocardiographic parameters between the three groups of TR

*Ratio of longest/ shortest annulus diameter

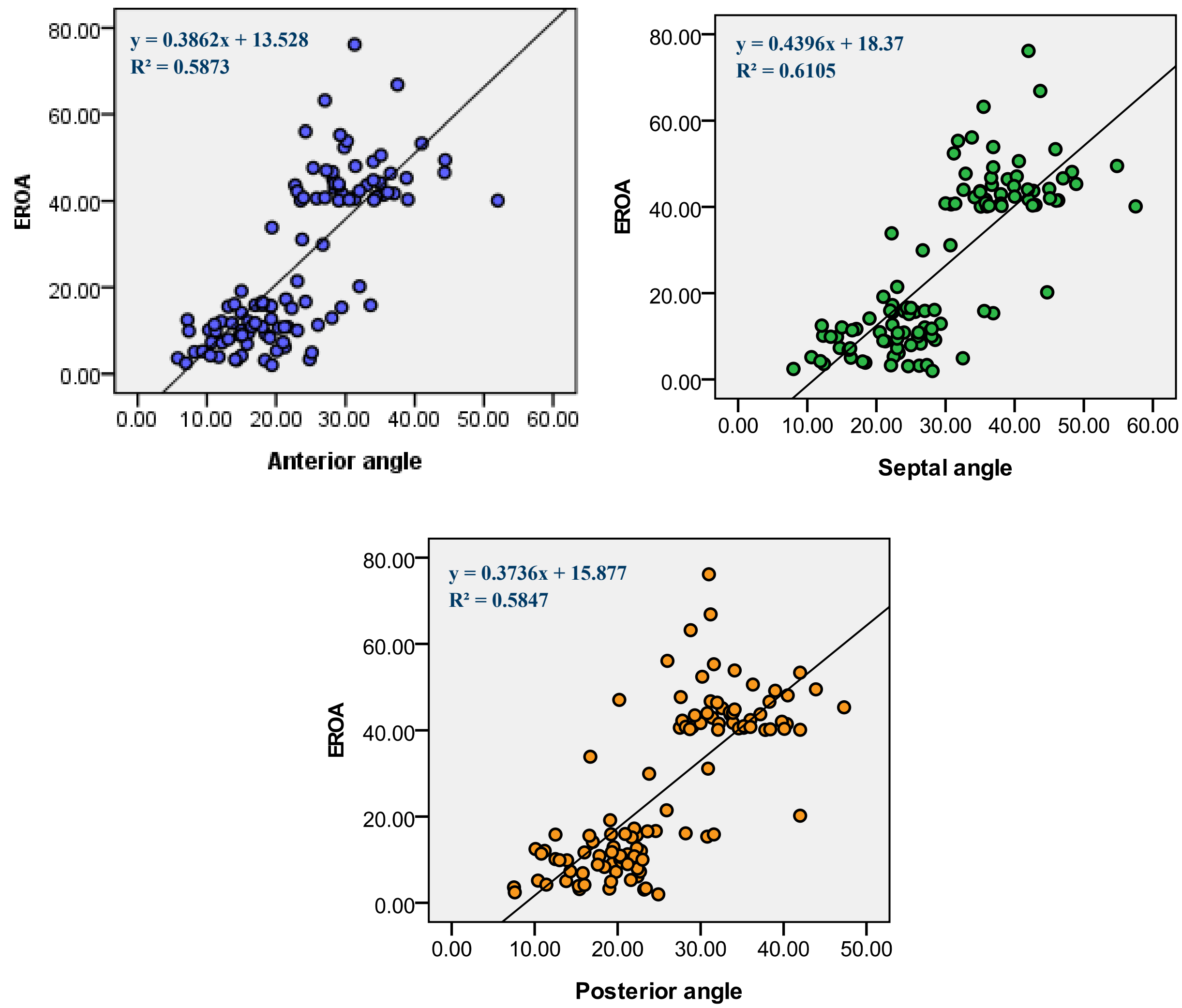

Figure 16. Scatter plots showing relationship of angle between tricuspid annulus plane and the anterior, septal, posterior leaflets with effective regurgitant orifice area

	Correlation with TV tethering height	*p* (2 tailed)	Correlation with Effective regurgitant orifice area	*p* (2 tailed)
	Correlation coefficient, r		Correlation coefficient, r	
Septal angle	0.796	0.01	0.781	0.01
Posterior Angle	0.760	0.01	0.765	0.01
Anterior Angle	0.760	0.01	0.766	0.01

Table17. Correlations of angle between tricuspid annulus plane and the anterior, septal, posterior leaflets with effective regurgitant orifice area and TV tethering height

D. Determinants of severity of functional TR in patients with pulmonary hypertension

Figure 17 shows the distribution of functional TR severity in patients with and without pulmonary hypertension. Patients with pulmonary hypertension (estimated pulmonary artery systolic pressure, PASP more than 50) had higher proportion of patients with severe TR. Nevertheless, functional TR was less than severe in a substantial proportion of patients with pulmonary hypertension (38.6% of patients with PASP > 50 had only mild or moderate TR).

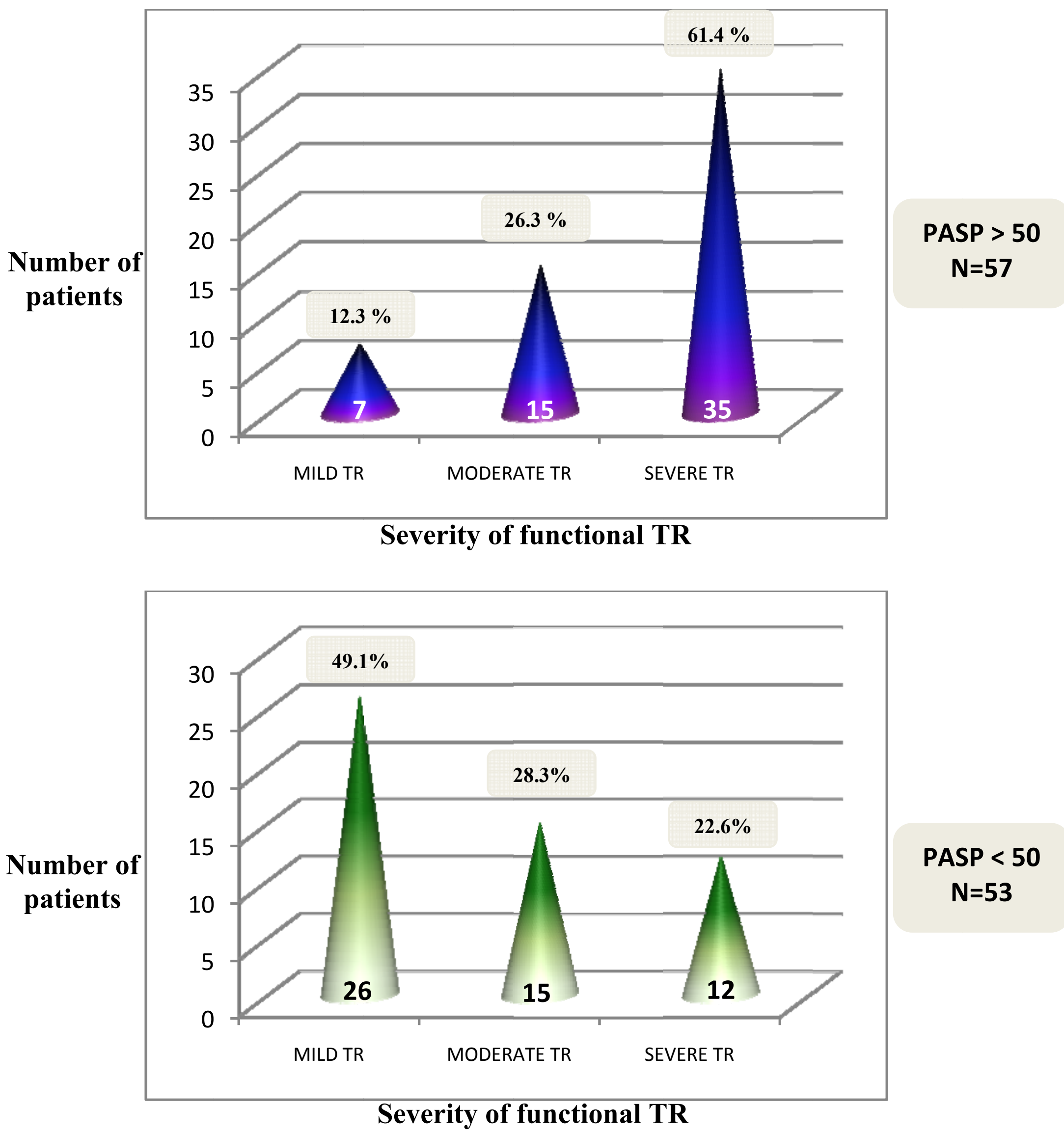

Figure 17. Distribution of TR severity in patients with and without pulmonary hypertension.

In patients with PASP > 50, tricuspid annulus dimension, tethering height and area, right ventricular basal dimension and right ventricular end systolic eccentricity index showed good correlation with effective regurgitant orifice area (table 18). Peak TR gradient was not associated with the severity of TR. End diastolic tricuspid annulus dimension (p =0.004) and tethering height (p= 0.009) were the independent determinants of functional TR severity by multivariate analysis in this population.

Variable	Correlation coefficient, r	*p*
Right Ventricular Basal dimension	0.602	**< 0.001**
Right Ventricular Mid dimension	0.436	**0.001**
Right Ventricular long- axis dimension	0.378	**0.004**
Right Ventricular FAC	- 0.272	0.041
Right Ventricular Tei index	0.239	0.073
Tricuspid annulus dimension, end diastolic	0.814	**< 0.001**
Tricuspid annulus dimension, end systolic	0.737	**< 0.001**
Tethering area	0.683	**< 0.001**
Tethering Height	0.736	**< 0.001**
Right atrial End-systolic area	0.445	**0.001**
Peak TR Gradient	0.181	0.178
Right Ventricular Spherical index	0.429	**0.001**
Right Ventricular End systolic EI#	0.525	**< 0.001**
Right Ventricular End diastolic EI#	0.395	**0.002**
Left Ventricular ejection fraction	- 0.200	0.136
Left Ventricular spherical index	0.049	0.719

Table 18. Correlations of echocardiographic parameters with effective regurgitant orifice area in patients with PASP > 50. #EI- Eccentricity index.

Validity and reproducibility

Inter and intra observer variations in the measurements of tricuspid annulus diameter, tethering area, tethering height, end-systolic eccentricity index and septal angle were assessed by analyzing ten random images by two independent blinded investigators and by the same principal investigator at separate time points. Lin's concordance correlation coefficient was calculated for the observed measurements. Good correlation was observed for all the parameters (table 19).

A

Variable	Lin's concordance correlation coefficient, ρ_c	95 % CI
End-diastolic tricuspid annulus diameter	0.915	0.801 - 0.965
Tethering distance	0.822	0.501 - 0.944
Tethering area	0.823	0.466 - 0.949
Right ventricular End-systolic EI#	0.809	0.544 - 0.927
Septal Angle	0.868	0.608 - 960

B

Variable	Lin's concordance correlation coefficient, ρ_c	95 % CI
End-diastolic tricuspid annulus diameter	0.959	0.866 - 0.988
Tethering distance	0.842	0.533 - 0.953
Tethering area	0.959	0.854 - 0.989
Right ventricular End-systolic EI#	0.853	0.538 - 0.959
Septal Angle	0.802	0.563 - 0.917

Table 19. Inter (A) and intra observer (B) variability. #EI- Eccentricity index.

DISCUSSION

The present study, a prospective observational study, evaluated the mechanisms and determinants of severity of functional TR by echocardiography. The study demonstrated that tricuspid valve tethering distance, end-diastolic tricuspid annulus diameter, end-systolic right ventricular eccentricity index and end systolic right atrial area independently determined severity in patients with functional TR who were referred for echocardiographic assessment with various clinical conditions. Right ventricular end- diastolic and end- systolic area, right ventricular FAC and right ventricular Tei index (reflecting right ventricular systolic function), estimated pulmonary artery systolic pressure, and left ventricular function did not independently determine functional TR severity. The strong positive correlations of tricuspid valve tethering distance, end-diastolic tricuspid annulus diameter and the eccentricity index with the functional TR severity emphasizes the importance of tricuspid valve deformations and changes in right ventricular geometry in the pathogenesis of this condition.

Unlike the case with mitral regurgitation, impact of alterations of right ventricular morphology and function on functional TR has been less well characterized. Review of recent medical literature revealed only a few studies on this aspect. One of the key reasons for the lack of investigations on this topic could be that until recently, underlying left sided pathological processes were give much more importance and management was tailored to correcting them. However, as mentioned earlier, several recent studies have shown that functional TR progresses even after correction of left sided pathology in a significant proportion of patients. Another reason for the lack of data could be that there has been no well characterized method for assessing the right ventricle. As a consequence mechanisms of functional TR have not been well evaluated whereas mechanisms of functional mitral regurgitation have been thoroughly studied.[68-71] Delineation of the various mechanisms and determinants of functional TR are of utmost importance considering the therapeutic implications and the impact it has on the prognosis of various cardiac and non cardiac conditions. Recognition of importance of functional TR formed the impetus for the present study.

As mentioned earlier, the normal functioning of tricuspid valve requires coordination and integrity of various components such as the leaflet tissue, supporting annular ring, chordae tendinae, papillary muscles, right atrium and right ventricular myocardium.[11] Any abnormality of one of the above mentioned components can cause significant regurgitation. In functional TR, the valve leaflets are structurally normal. Tricuspid annulus dilatation and inadequate leaflet coaptation secondary to displacement of papillary muscles are considered to be the key mechanisms in the genesis of functional TR as shown in earlier studies.[39,72,73] The present study affirmed the relationship between tricuspid annulus diameter and severity of functional TR as demonstrated in earlier studies.[39,47,74] This study also showed that TV tethering height is another strong determinant of functional TR severity.

Relationship between morphological changes of right sided chambers and functional TR

Interestingly, pulmonary artery systolic pressure, right ventricular systolic function and right ventricular chamber size did not independently determine functional TR severity suggesting that neither pulmonary hypertension nor enlargement of right ventricle with or without systolic dysfunction is a pre requisite for functional TR regurgitation. However changes in right ventricular shape reflected by end-systolic eccentricity index appeared to be important in the mechanism of functional TR. Another recent study looking at atrial and ventricular factors that are important in the mechanism of functional TR, found spherical index of the right ventricle in addition to tethering height and right atrial area, to be significantly associated with severity of regurgitation.[48] Thus changes in right ventricular shape seem to outweigh ventricular size alterations in determining functional TR severity. However, right ventricular enlargement was shown to influence both tethering height and tricuspid annulus dimension in this study (tables 9 and 10).

Another parameter which was shown to determine functional TR severity in our study was end systolic right atrial enlargement. This is not surprising considering the anatomical location of tricuspid valve between the two right sided chambers. Another factor which might have contributed to the pathogenesis is atrial fibrillation. Severe TR group had significantly greater proportion of patients with atrial fibrillation secondary to the underlying left sided valve pathology and possible left atrial enlargement. Atrial fibrillation has been shown to cause right atrial dilatation with potential widening of the adjacent tricuspid annulus which can in turn result in significant TR.

Determinants of tricuspid valve alterations

Enlargement of the TV annulus and leaflet tethering were found to be the significant parameters contributing to functional TR severity. Annular dilatation is postulated to contribute to tricuspid regurgitation by limiting the amount of leaflet overlap during valve closure. Right ventricular basal dimension ($p < 0.001$), right ventricular end systolic eccentricity index ($p < 0.001$) and right atrial end-systolic area ($p < 0.001$) were identified as the parameters that independently determined end-diastolic tricuspid annulus. Tricuspid annulus is shared by the two right sided chambers. Thus enlargement of right sided chambers (right atrium) or alteration of its shape (relative dilation of the basal segment of the right ventricle) is important in determining tricuspid annulus dimension. Similarly right sided chamber enlargement and changes in the shape of the right ventricle (eccentric enlargement) determined tethering height. Right ventricular geometry changes can lead to papillary muscle displacement resulting in tethering of the valve leaflets.

Role of pulmonary hypertension

Although pulmonary artery systolic pressure correlated weakly with TR severity in the entire study population, it did not independently determine functional TR severity in this study. When patients with pulmonary hypertension (estimated PASP) were analyzed, significant association with TR severity was noted for tricuspid valve deformations and eccentric right ventricular enlargement. This suggests that remodeling of the right heart rather than the absolute value of the PASP which is important for functional TR.

Insights from 3-Dimensional echocardiographic assessment

Changes in the tricuspid annulus such as increased area and circumference of the annulus with the annulus assuming a relatively circular shape were observed with increasing severity of functional TR. A greater enlargement of the antero-posterior dimension than the septal-lateral dimension was noted indicating preferential enlargement of the annulus along its free wall (figure18). Angle between the septal tricuspid leaflet and the annulus plane showed the best correlation with the TV tethering height and effective regurgitant orifice area.

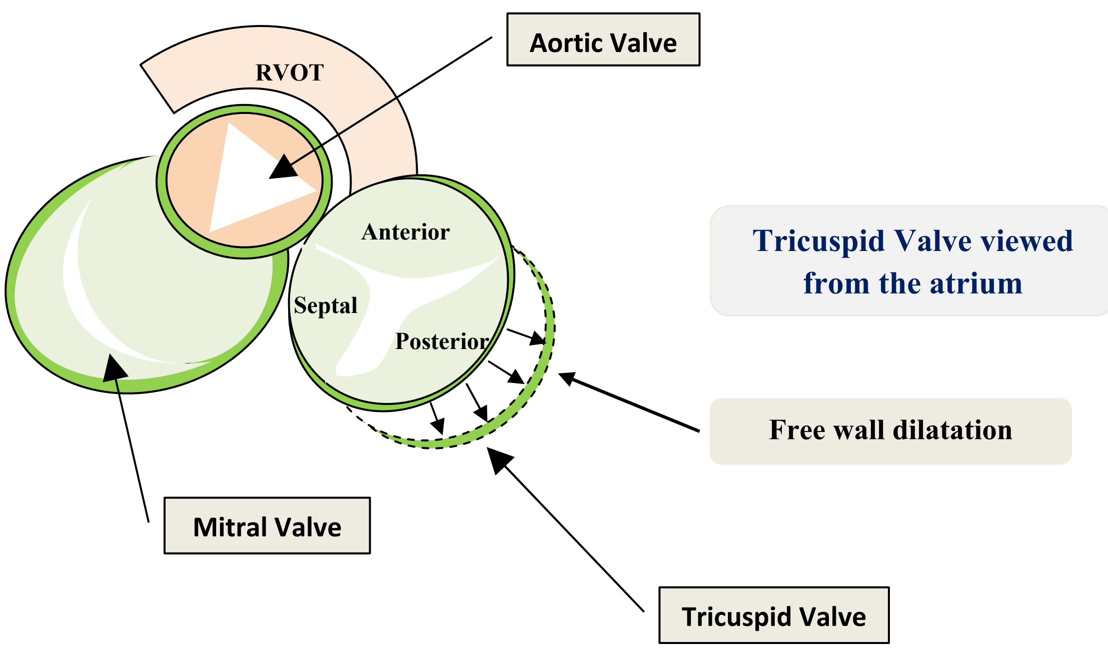

Figure 18. Tricuspid valve viewed from the atrial side showing dilatation of the annulus along the free wall (dashed line).

Comparison with other studies

The results of the present study were comparable with that of other studies (table 20)

Study	Study type	Sample size of study patients (after exclusions)	Patient population	Independent predictors
Kim et al[47]	Prospective Observational 2-D Echo	64	Chronic right ventricular dilation (Valvular heart disease-36%)	* TV tethering area * Right Ventricular End systolic EI# * End diastolic tricuspid annulus diameter
Fukuda et al[8]	Retrospective 2-D Echo	216	Post tricuspid annuloplasty	* TV tethering distance
Ton-Nu et al[12]	3-D Echo	35 functional TR patients	Clinical heart failure patients with at least moderate TR	*Tricuspid valve annular area *Right ventricular diastolic area *Ratio of tricuspid annulus dimensions
Song et al[75]	Observational 3-D Echo	53	Patients with various degrees of TR	* Septal-lateral annulus diameter * Right Ventricular inlet dimension * Right Ventricular end-systolic volume * Septal and anterior leaflet tenting angles
Present study	Prospective Observational 2-D & 3-D Echo	110 functional TR subjects	Patients aged 18 years and above referred for echocardiography (Rheumatic Valvular heart disease- 70%)	* TV tethering distance * Right Ventricular End systolic # * End diastolic tricuspid annulus diameter * Right atrial end systolic area

Table 20. Comparison with other studies. #EI- Eccentricity index.

To the best of our knowledge, this is the first Indian study done to evaluate the determinants of functional TR severity. A large proportion of our patients were rheumatic valvular heart disease which is in contrast to non rheumatic left sided valve lesions or heart failure patients in western studies. Nevertheless, factors involved in the pathogenesis of functional TR are likely to be identical. When compared to the findings of the study by Kim et al[47], we found TV tethering distance and right atrial end systolic area to determine severity. Three dimensional echocardiographic results of our study are in keeping with the findings of the study by Ton- Nu et al.[12]

Feasibility

In this study, assessment of right ventricle and tricuspid valve was done using simple two dimensional echocardiographic measurements. These parameters are practically easy to record and require only obtaining a good quality image. Recording of the images took an average of two minutes and measurements took average of another four minutes to complete. Offline evaluation of the data sets took an additional average of five minutes. Measurements obtained were valid and reliable as shown by the good inter and intra-observer variability.

Suggested Mechanisms of functional TR based on the results of the present study

Based on the results of the study, likely mechanisms of functional TR were proposed (figure 19). In the initial stages, there is a selective dilatation of the basal aspect of the right ventricle which results in dilatation of annulus. Depending on the amount of overlap of the leaflets, there may or may not be regurgitation. As dilatation progresses, failure of coaptation increases and the degree of functional TR increases. Atrial fibrillation may contribute to significant right atrial enlargement. Enlarged right atrium may add to the dilatation of the annulus and worsen functional TR. Lastly, with eccentricity and progressive right ventricular enlargement, tethering of the valve leaflets occur and worsen the degree of regurgitation.

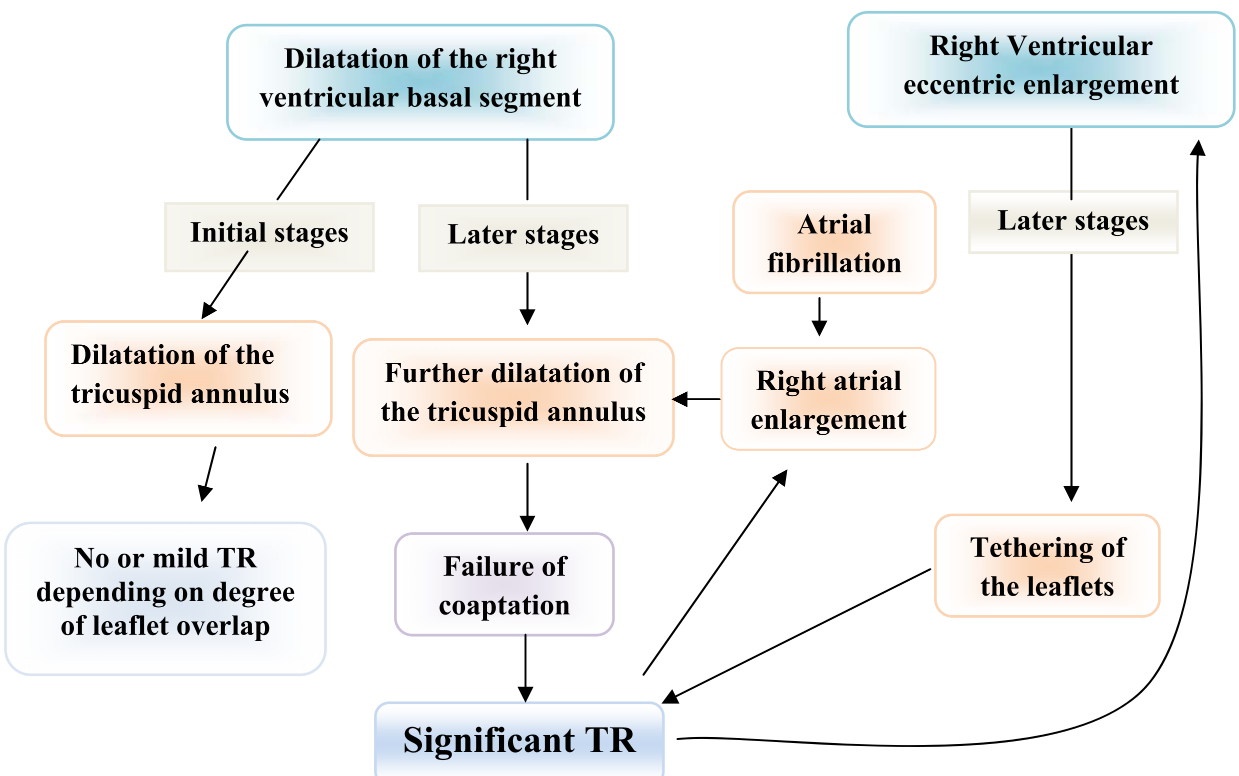

Figure 19. Suggested mechanisms for functional TR based on the results of the present study

POTENTIAL CLINICAL IMPLICATIONS OF THE PRESENT STUDY

As mentioned earlier functional TR is a complex clinical entity and is associated with significant morbidity. There has been a greater impetus to perform annuloplasty at the time of left heart surgery if tricuspid annulus is found to be enlarged. However with the current techniques, functional TR persists or even progresses in a significant proportion of patients. The observations of the current study have several potential clinical implications, some of which are listed below.

1. A strong correlation was shown between TV tethering height, end- diastolic tricuspid annulus diameter and functional TR severity. Cut off values estimated could be used as additional supportive criteria in assessing severity of functional TR.

2. A detailed evaluation of the tricuspid valve apparatus, including that of the tricuspid annulus dimension and the tethering height should be considered mandatory in patients with functional TR, especially those who are being considered for left heart surgery. Cut off values of end diastolic tricuspid annulus diameter that reliably predicted severe regurgitation was 3.59 cm. Current guidelines recommend tricuspid annuloplasty if diameter is greater than 4.0 cm. Our values suggest that cut off values for annuloplasty should be even lower especially in patients with rheumatic heart disease. Lower cut off values have been suggested by other studies as well.[21,76,77]

3. This study has shown that in addition to end diastolic annulus dimension, parameters such as TV tethering height and eccentricity indices also contribute to TR severity. Hence, performing an annuloplasty may not be enough in patients who have severe tethering of the leaflets. Newer surgical techniques to address tethering should be developed. One such technique that is being

recently developed is the anterior tricuspid leaflet augmentation.[78] Anterior tricuspid leaflet augmentation involves augmentation of the anterior leaflet with the use of an autologous pericardial patch followed by implantation of Carpentier–Edwards annuloplasty ring. This results in increased size and leaflet coaptation area, allowing better coaptation with a decreased tension within the ventricle. Tricuspid valve replacement is another option for patients with severe tethering.

4. Dilatation of the tricuspid annulus was found to be in the direction of free wall. Hence annuloplasty focussing on this aspect may help in reducing the degree of regurgitation.

In short, observations of this study can help in clinical evaluation of functional TR in patients with left side valve disease and guide future research on this topic.

FUTURE DIRECTIONS AND NEW QUESTIONS RAISED

Future studies done with serial echocardiographic follow up may help to identify the sequential geometric changes of right sided chambers and tricuspid annulus in functional TR patients. This will help to further clarify the mechanisms involved in the pathogenesis of this condition.

Technological innovations in 3-dimensional echocardiography with regard to acquisition, better imaging and analytic software may enhance the clinical application of this modality for the assessment of the TV.

Factors involved in the mechanism of tricuspid regurgitation after surgical procedures such as annuloplasty were not assessed in the present study. Future three dimensional echocardiographic studies may play a greater role in identifying mechanisms and factors that determine severity in patients who develop regurgitation after tricuspid annuloplasty.

STRENGTHS AND LIMITATIONS OF THE PRESENT STUDY

Strengths of the study: Following were considered to be the strengths of the study.

The present study was a prospectively conducted observational study with data likely to represent real patient population in clinical practice.

Limitations: Several limitations should be acknowledged in the present study, many of which are primarily related to the echocardiographic measurements. Some of the key limitations are stated below.

1. Because of the complex shape and highly trabeculated nature of the right ventricle, accurate estimation of the right ventricular function and size are difficult to make with the currently available two dimensional imaging techniques. Right ventricular imaging is highly dependent on transducer position. Hence for the purpose of this study, only patients with good echocardiographic window were included and the right ventricular measurements were done from the apical four chamber window. Even then, it is possible some amount of error might have occurred while measuring some of these parameters.

2. A significantly high number of patients with rheumatic heart disease as the etiology of the left sided valve lesion were present in our study. Even though substantial care was taken to exclude patients with organic rheumatic tricuspid valve involvement, it is possible that patients with minimal rheumatic involvement were included. However this error is likely to be negligible as previous reports have shown 2-dimensional echocardiography to be useful in evaluating rheumatic etiology of tricuspid valve diseases.[79]

3. The grading of tricuspid regurgitation is often considered to be highly subjective and there is no perfect standard for classifying functional TR. Also severity of regurgitation is likely to vary depending on the respiratory changes, loading conditions and contractility. In this study, severity of functional TR was graded incorporating several parameters prescribed by various guidelines. Also, values of the parameters in this study were averaged over three cycles for sinus rhythm and five cycles for atrial fibrillation.

4. Serial echocardiographic follow up was not part of the study design and hence one may argue to comment whether right sided chamber enlargement is the result or cause of functional TR. Functional TR can be thought of as a vicious remodeling cycle in which TR leads to right ventricular remodeling which in turn leads to further worsening of TR. Kim et al[47] observed a lack of eccentric right ventricular enlargement in patients with chronic right ventricular dilatation due to TR associated with organic pathology such as chordal rupture. This suggests that change in right ventricular geometry change is not the result, but the cause of functional TR.

5. Limitations of 2-dimensional echocardiography in assessing complex three dimensional structures like the right ventricle are well known. However three dimensional imaging of the right ventricle is still limited by technical problems and assessment of datasets requires additional costly software.

CONCLUSION

Main findings of the present study are summarized below.

- Tricuspid valve tethering distance, end-diastolic tricuspid annulus dimension, end-systolic eccentricity index and end-systolic right atrial area independently determine severity of functional TR
- Tricuspid annulus end diastolic diameter value of > 3.59 cm and tethering distance > 0.79 cm predicted patients with more than moderate functional TR reliably
- Right ventricular basal dimension, right atrial end-systolic area and right ventricular end systolic eccentricity index determine end diastolic tricuspid annulus dimension
- Right ventricular end-diastolic area, right atrial end-systolic area and right ventricular end systolic eccentricity index determine tricuspid valve tethering height
- End diastolic tricuspid annulus dimension and tethering height were the determinants of severity in patients with pulmonary artery hypertension.
- With increasing severity of functional TR, tricuspid annulus assumes a relatively circular shape with greater increase in the antero-posterior annulus dimension.
- Degree of tethering was found to correlate with functional TR severity in all three leaflets. Angle between septal leaflet and tricuspid annulus plane correlated best with severity.

This study emphasizes the role of tricuspid annulus dilatation and TV leaflet tethering in the pathogenesis of functional TR. Geometric alterations of the right atrium and right ventricle contributes significantly to the development of functional TR. Findings of this study have potential mechanistic and therapeutic implications.

CONFLICTS OF INTEREST

- Limited time period trial versions of echocardiographic software were used for analysis of some of the echocardiographic parameters in this study. These software programs were provided by Philips Medical Systems and Tom Tech Systems, Germany. However no financial grants were obtained from any of these companies. They were also not involved in formulating the study protocol, recruitment of patients, data analysis or publication of results of the study.

- No financial grants were taken from any other sources, including that of the FLUID RESEARCH of the Christian Medical College hospital, Vellore.

- There were no other conflicts of interest.

MASTER DATA SHEET

Patients

	Name	ID	Age	Sex	Height	Weight	BSA	Rhythm	RVmid	RVBasal	RVlong	RVEDA	RVESA	RVFAC
1.	Sangeetha	647745	20	2	151	42	1.34	1.00	3.10	3.90	5.20	15.40	8.00	48.05
2.	Nazeera	267142	22	2	157	45	1.42	1.00	3.40	4.40	7.00	26.60	15.11	43.20
3.	Krishnakumar	818989	18	1	130	22	.91	1.00	2.60	3.00	4.90	11.35	5.90	48.02
4.	Sarath Kumar	190237	18	1	160	48	1.48	1.00	3.50	4.10	6.30	19.80	11.20	43.43
5.	Zamruth	873457	53	2	146	50	1.40	1.00	2.90	4.00	6.30	13.70	7.26	47.01
6.	Malarkodi	472714	35	2	155	59	1.57	2.00	2.20	4.10	6.10	17.30	10.10	41.62
7.	Anbu Kumar	540013	37	1	165	51	1.55	1.00	2.70	4.10	6.70	17.69	10.80	38.95
8.	Rani P	421394	51	2	163	54	1.57	2.00	2.00	2.60	6.29	13.00	8.10	37.69
9.	Sulochana	447797	34	2	148	38	1.26	1.00	3.60	4.70	6.96	24.86	16.70	32.82
10.	Rogini	834512	45	2	144	41	1.28	1.00	2.90	4.40	5.40	14.50	8.10	44.14
11.	Senthil S	817686	30	1	161	48	1.48	1.00	3.40	4.09	7.01	17.43	10.47	39.93
12.	Valli	829150	40	2	154	50	1.46	1.00	2.60	3.52	5.36	13.10	7.07	46.03
13.	Nurul Hoda	789507	72	1	172	64	1.76	1.00	3.10	3.90	5.82	17.00	10.10	40.59
14.	Kumari Bai	718782	20	2	150	38	1.27	1.00	2.93	4.20	5.70	15.90	8.94	43.77
15.	Shamim Akhtar	801553	48	1	173	73	1.87	1.00	2.70	3.40	5.90	15.00	9.00	40.00
16.	Kothandan M	201397	46	1	156	45	1.41	1.00	2.50	3.90	6.39	13.80	7.90	42.75
17.	Narendranath	811291	81	1	163	44	1.44	1.00	3.32	4.50	6.58	20.10	11.10	44.78
18.	Vijaya	097264	18	2	156	41	1.35	1.00	3.17	4.27	6.51	22.90	15.80	31.00
19.	Shantha	507139	44	2	157	41	1.36	2.00	2.52	2.91	5.92	15.80	8.22	47.97
20.	Govindammal	589740	66	2	160	49	1.49	2.00	2.54	3.65	5.34	15.70	9.20	41.40
21.	Arun Kumar	840116	46	1	171	51	1.59	1.00	3.60	4.50	6.80	20.73	13.10	36.81
22.	ShantiRanjan	839059	46	1	154	55	1.52	1.00	2.63	3.42	6.00	14.39	6.86	52.33
23.	Bula Kumar	851332	48	2	145	35	1.20	1.00	2.57	3.61	7.58	17.30	9.30	46.24
24.	Subash	945209	18	1	154	38	1.30	1.00	2.86	3.85	5.75	15.30	7.86	48.63
25.	Palani	757166	18	1	144	28	1.09	1.00	3.35	4.22	6.05	16.30	8.83	45.83

26.	Shenbagam	854585	20	2	158	38	1.32	1.00	2.75	3.97	5.84	16.50	10.90	33.94
27.	Mathiur Rahman	854138	34	1	177	63	1.78	2.00	2.02	3.50	6.96	17.60	11.00	37.50
28.	unnamalai	485997	33	2	153	57	1.54	1.00	2.98	3.74	6.85	17.60	12.00	31.82
29.	Parimala	971158	44	2	154	58	1.56	1.00	1.80	2.77	4.88	11.10	5.69	48.74
30.	Prabha	057218	38	2	154	47	1.42	1.00	2.01	3.18	6.39	15.70	8.31	47.07
31.	Adi Narayan	855044	70	1	156	48	1.45	1.00	2.66	5.37	7.71	25.90	13.30	48.65
32.	Govindamma	291495	50	2	152	54	1.49	1.00	2.50	3.70	7.37	16.00	11.00	31.25
33.	Tamilarasi	118763	22	2	168	49	1.54	1.00	3.55	4.59	6.92	23.00	13.20	42.61
34.	Sudhir	814510	36	1	163	50	1.52	1.00	3.42	4.66	7.40	18.00	11.10	38.33
35.	Dhanabackiam	647567	29	2	161	51	1.52	1.00	3.55	4.83	7.60	24.22	19.00	21.55
36.	Lakshmi	806089	55	2	153	47	1.42	2.00	3.06	4.08	6.90	17.07	9.76	42.82
37.	Selvakumar	714070	21	1	163	52	1.55	1.00	3.50	4.10	6.80	17.10	9.56	44.09
38.	Vijayakanth	809117	22	1	173	51	1.60	1.00	3.00	3.90	7.40	18.00	9.00	50.00
39.	Lalitha	367403	58	2	146	44	1.33	1.00	3.90	5.30	7.70	22.80	14.80	35.09
40.	Neelammal	797740	52	2	153	39	1.31	1.00	4.10	4.80	5.40	23.50	15.00	36.17
41.	Mamata Mondal	020388	38	2	156	32	1.22	1.00	3.40	4.16	6.21	18.60	12.10	34.95
42.	Shenbagavalli	880655	30	2	161	44	1.43	1.00	2.70	3.40	5.00	16.00	11.00	31.25
43.	Ponnuswamy	790998	66	1	165	50	1.53	1.00	2.70	3.80	6.10	19.00	12.00	36.84
44.	Karumbathi	699238	38	1	164	60	1.65	2.00	3.20	3.90	7.00	25.30	15.60	38.34
45.	Udayakumar P	394476	28	1	172	52	1.61	1.00	3.00	4.30	7.20	21.90	14.50	33.79
46.	Rani V	782418	56	2	150	34	1.22	2.00	2.90	4.60	6.35	18.30	9.61	47.49
47.	Rajeswari	106439	18	2	147	39	1.27	1.00	3.60	5.30	6.30	19.87	11.74	40.92
48.	Shova Sinha	936278	49	2	150	65	1.60	2.00	2.20	4.05	6.34	13.76	7.94	42.30
49.	Selva Kumari	180539	37	2	159	46	1.44	1.00	3.70	4.97	6.08	18.70	10.85	41.98
50.	Sivagami	133394	32	2	153	29	1.15	2.00	2.10	2.70	5.36	11.84	7.13	39.78
51.	Saroj Yadav	833349	40	2	153	53	1.49	2.00	3.10	3.70	6.10	16.80	8.70	48.21
52.	Jebamani	691869	34	2	141	51	1.38	1.00	2.64	3.62	6.35	17.52	9.54	45.55
53.	Malar	188131	39	2	155	50	1.47	2.00	3.40	4.10	6.01	15.56	9.18	41.00
54.	Selvam	122287	35	1	163	65	1.72	1.00	4.19	5.00	8.30	31.00	20.19	34.87
55.	Jaikishan	802242	65	1	167	43	1.45	2.00	2.80	3.10	6.60	15.00	10.96	26.93

56.	Kannammal	987375	35	2	153	67	1.65	2.00	2.35	3.73	6.26	13.70	8.84	35.47
57.	Rose	254826	39	2	153	45	1.39	2.00	2.57	3.74	5.60	15.90	11.40	28.30
58.	Rizwanullah	055663	59	1	170	70	1.81	2.00	3.54	4.41	7.62	23.80	14.90	37.39
59.	Deviakiammal	853702	74	2	156	42	1.37	2.00	2.51	3.93	5.97	17.20	10.30	40.12
60.	Ramkumar	858695	36	1	154	41	1.34	1.00	2.90	4.00	5.18	15.00	10.30	31.33
61.	Rajeswari	991737	35	2	152	50	1.45	1.00	2.47	3.32	6.05	14.30	8.30	41.96
62.	Raji	793469	51	2	138	43	1.26	2.00	2.32	3.59	5.62	15.10	8.67	42.58
63.	Boobalan	838975	31	1	165	55	1.60	1.00	5.58	3.49	6.66	26.10	16.50	36.78
64.	Prema	904545	40	2	160	67	1.32	2.00	4.98	6.10	7.80	29.81	17.10	42.64
65.	Shyamal Patra	803969	39	1	167	59	1.66	1.00	4.10	5.30	8.45	34.40	24.16	29.77
66.	Vamathi	386556	38	2	153	61	1.58	2.00	3.30	4.10	6.95	23.30	13.90	40.34
67.	Nila Khatun	812113	26	2	161	52	1.53	2.00	3.50	5.10	7.10	25.70	15.20	40.86
68.	Deepti	814183	49	2	152	38	1.29	2.00	3.90	5.70	6.80	30.86	19.73	36.07
69.	Govindaraj	573966	79	1	172	48	1.55	2.00	3.20	3.70	6.40	17.00	9.70	42.94
70.	Veena Devi	812433	45	2	152	34	1.23	2.00	3.32	4.56	6.90	20.40	11.80	42.16
71.	Ananda Paul	953948	52	1	160	52	1.53	1.00	4.80	6.40	7.80	37.43	24.70	34.01
72.	Uthirakumar	773446	22	1	168	59	1.67	1.00	3.80	5.40	6.30	24.40	13.80	43.44
73.	Selvi	806969	35	2	158	55	1.55	1.00	4.30	5.10	8.20	35.00	23.70	32.29
74.	Simson Mochar	795883	58	1	165	43	1.44	1.00	4.20	5.50	7.30	29.00	18.80	35.17
75.	Harlin Rongha	770812	30	1	171	61	1.71	2.00	5.20	6.50	8.10	41.90	25.10	40.10
76.	Kalpana	815920	30	2	130	41	1.19	1.00	3.80	4.80	7.10	26.00	20.10	22.69
77.	Kamatchi	586712	56	2	155	65	1.64	2.00	3.40	4.90	6.90	25.03	15.50	38.07
78.	Anowar Bibi	789661	34	2	149	43	1.34	2.00	2.80	3.80	4.70	20.40	16.80	17.65
79.	Stella	601286	45	2	146	33	1.18	2.00	3.20	4.10	5.70	17.10	12.00	29.82
80.	Ramamurthy	423256	46	1	163	62	1.67	1.00	4.10	5.60	7.70	26.34	17.49	33.60
81.	Samsuddin Ansari	822130	45	1	144	44	1.32	1.00	3.10	4.70	6.80	18.32	13.10	28.49
82.	Sasipriya	824669	28	2	156	41	1.35	1.00	6.40	6.40	7.40	38.70	26.75	30.88
83.	Mamata Layek	772526	46	2	152	47	1.41	1.00	3.80	5.40	7.70	25.20	16.80	33.33
84.	Palani	936065	36	1	164	58	1.63	2.00	3.50	5.10	6.40	21.20	11.00	48.11
85.	Rani A	921834	54	2	150	37	1.26	2.00	5.00	6.70	8.05	42.90	28.00	34.73

86.	Sarada Devi	356600	37	2	157	47	1.44	2.00	3.51	4.50	5.20	16.70	9.30	44.31
87.	Kapuri Devi	651668	53	2	145	40	1.27	2.00	3.05	4.20	7.10	22.00	12.02	45.36
88.	Rani	836152	55	2	153	73	1.71	1.00	3.20	4.50	6.80	19.30	11.10	42.49
89.	Arup Middya	219451	36	1	158	57	1.57	1.00	3.86	5.36	7.45	29.70	21.10	28.96
90.	Janaki	329307	50	2	148	57	1.50	2.00	3.50	4.70	6.40	26.36	13.30	49.54
91.	Tapan Dutta	837082	51	1	158	65	1.66	1.00	3.80	4.80	6.90	25.10	18.00	28.29
92.	Jegan	925961	19	1	172	46	1.53	1.00	5.20	6.90	7.68	57.01	46.39	18.63
93.	Nagarani K	803520	30	2	142	43	1.29	1.00	3.20	3.80	7.00	17.11	11.78	31.15
94.	Usha	453241	39	2	150	40	1.30	2.00	3.30	4.80	6.70	18.00	11.79	34.50
95.	Mani	054550	45	1	163	47	1.48	2.00	3.65	5.02	8.53	34.22	22.30	34.83
96.	Jegadeesan	147654	44	1	163	60	1.64	1.00	3.90	5.40	6.88	28.76	14.74	48.75
97.	Navamani	664841	64	2	140	40	1.24	1.00	3.55	4.78	5.51	19.20	11.16	41.88
98.	Rajakumari	807061	37	2	146	35	1.21	1.00	4.30	5.26	6.80	29.80	19.80	33.56
99.	Poongavanam	629747	56	2	155	42	1.36	2.00	3.52	5.39	5.81	18.50	10.90	41.08
100.	Md Yacob	466714	55	1	166	57	1.63	2.00	3.60	4.60	6.40	18.14	10.85	40.19
101.	Nirmala Maji	711006	56	2	142	42	1.28	2.00	4.30	6.90	7.40	32.50	19.80	39.08
102.	Pushpa Bala	037380	70	2	137	40	1.22	2.00	3.54	5.69	8.04	33.10	15.80	52.27
103.	Kishun Saw	854086	28	1	173	47	1.55	1.00	4.48	6.60	7.38	40.80	30.30	25.74
104.	Roshin Bauri	851557	57	2	145	44	1.32	1.00	4.50	5.89	7.44	36.40	25.30	30.49
105.	Sakthivelmurugan	805006	33	1	154	48	1.43	2.00	3.60	5.90	6.36	20.60	14.60	29.13
106.	Shahabaz Alam	818185	15	1	156	34	1.25	1.00	4.60	5.40	7.34	38.40	32.30	15.89
107.	Devaki	428989	44	2	157	58	1.58	2.00	3.10	4.20	7.10	22.00	15.00	31.82
108.	Swapan Pal	726332	42	1	170	54	1.62	2.00	3.76	5.08	5.90	25.20	14.10	44.05
109.	Subramani K	423622	65	1	163	55	1.58	2.00	3.70	4.90	6.50	25.00	15.00	40.00
110.	Uma	467241	30	2	153	53	1.49	2.00	3.56	4.92	6.98	25.10	19.70	21.51

	Name	ID	RVTei	IVA	RAMajor	RAMinor	RAESA	TASYS	TADIAS	TAC	TAPSE	TETH.A	TETH.H	PeakTR Velocity
1.	Sangeetha	647745	.52	3.33	4.20	2.40	12.10	2.30	2.80	17.86	2.20	.85	.80	337.00
2.	Nazeera	267142	.46	3.60	5.10	4.70	18.00	2.88	3.26	11.66	2.23	1.15	.76	447.00
3.	Krishnakumar	818989	.40	2.31	3.60	2.70	13.10	1.60	2.16	25.93	2.04	.51	.58	357.00
4.	Sarath Kumar	190237	.53	3.60	4.40	3.30	12.20	2.20	2.50	12.00	2.13	.47	.44	228.00
5.	Zamruth	873457	.45	2.31	4.50	3.70	14.80	2.30	3.00	23.33	2.34	.54	.52	269.00
6.	Malarkodi	472714	.47	2.50	4.90	3.90	19.10	2.60	3.10	16.13	1.70	.72	.36	276.00
7.	Anbu Kumar	540013	.56	2.50	4.35	3.44	15.31	2.70	3.05	11.48	2.12	.68	.55	320.00
8.	Rani P	421394	.49	6.07	5.50	2.70	17.20	2.20	2.80	21.43	1.60	.38	.28	424.00
9.	Sulochana	447797	.59	2.86	4.50	4.40	14.80	2.50	2.87	12.89	1.95	1.00	.67	330.00
10.	Rogini	834512	.63	2.29	4.60	2.70	17.70	2.60	3.26	20.25	2.08	.81	.45	312.00
11.	Senthil S	817686	.74	3.13	4.60	3.00	11.20	2.45	3.05	19.67	2.60	.60	.45	277.00
12.	Valli	829150	.46	2.31	3.60	2.70	8.33	2.07	2.40	13.75	1.80	.42	.41	223.00
13.	Nurul Hoda	789507	.48	1.28	4.20	3.60	20.10	2.30	2.70	14.81	2.20	.95	.56	407.00
14.	Kumari Bai	718782	.42	5.94	5.30	3.85	20.40	2.10	2.67	21.35	1.76	.48	.30	346.00
15.	Shamim Akhtar	801553	.68	3.33	4.80	3.90	18.10	2.20	2.76	20.29	2.21	.68	.43	254.00
16.	Kothandan M	201397	.49	2.31	3.30	3.00	15.10	2.10	2.38	11.76	2.70	.67	.43	274.00
17.	Narendranath	811291	.44	5.71	3.60	3.30	13.80	3.02	3.36	10.12	2.16	1.20	.50	257.00
18.	Vijaya	097264	.70	3.81	4.80	3.53	16.10	2.84	3.18	10.69	2.25	.56	.43	358.00
19.	Shantha	507139	.49	3.75	4.50	3.90	14.80	2.41	2.72	11.40	1.89	.55	.30	261.00
20.	Govindammal	589740	.61	4.29	5.70	2.80	17.80	2.46	2.76	10.87	1.56	.46	.21	254.00
21.	Arun Kumar	840116	.54	5.24	4.40	3.40	12.33	2.65	3.25	18.46	2.16	.68	.46	259.00
22.	ShantiRanjan	839059	.44	3.71	3.62	2.64	11.10	2.30	2.70	14.81	1.97	.91	.40	309.00
23.	Bula Kumar	851332	.52	3.81	5.24	3.86	17.20	2.30	2.83	18.73	2.40	.72	.44	311.00
24.	Subash	945209	.56	2.64	4.50	2.62	9.08	2.71	3.20	15.31	2.46	.63	.29	263.00
25.	Palani	757166	.51	4.64	3.83	3.79	16.70	2.56	2.92	12.33	2.38	.42	.10	292.00
26.	Shenbagam	854585	.62	3.21	4.02	2.77	10.40	2.38	2.64	9.85	2.40	1.45	.57	274.00
27.	Mathiur Rahman	854138	.65	5.00	4.80	3.26	14.30	2.55	3.31	22.96	2.36	.52	.41	341.00
28.	unnamalai	485997	.68	2.81	3.88	2.94	12.80	2.10	2.50	16.00	2.38	.60	.43	258.00
29.	Parimala	971158	.51	4.29	4.31	2.07	14.80	2.52	2.78	9.35	2.34	1.06	.47	290.00

30.	Prabha	057218	.48	2.83	4.30	2.83	11.60	2.07	2.61	20.69	2.72	.62	.46	333.00
31.	Adi Narayan	855044	.61	2.17	5.30	4.93	21.10	2.89	3.32	12.95	2.03	1.29	.59	324.00
32.	Govindamma	291495	.62	1.79	3.80	3.20	17.10	2.30	2.56	10.16	2.13	.98	.45	309.00
33.	Tamilarasi	118763	.42	2.86	4.60	3.30	16.80	2.28	2.58	11.63	2.15	.71	.49	326.00
34.	Sudhir	814510	.55	3.21	5.60	4.70	21.56	2.74	3.56	23.03	2.70	1.80	.88	312.00
35.	Dhanabackiam	647567	.50	4.06	5.80	4.60	18.80	2.80	3.30	15.15	1.51	.87	.69	363.00
36.	Lakshmi	806089	.50	5.71	6.42	5.20	24.30	3.08	3.63	15.15	2.07	.80	1.11	244.00
37.	Selvakumar	714070	.58	4.76	4.40	3.83	17.90	2.72	3.05	10.82	2.37	.93	.60	311.00
38.	Vijayakanth	809117	.47	3.13	4.50	3.40	14.10	2.90	3.30	12.12	2.30	.78	.66	248.00
39.	Lalitha	367403	.52	3.57	5.90	5.30	20.30	2.89	3.37	14.24	1.80	1.59	.78	350.00
40.	Neelammal	797740	.56	2.40	4.80	4.70	18.10	2.80	3.40	17.65	1.60	1.35	.84	495.20
41.	Mamata Mondal	020388	.52	3.57	3.80	3.40	14.20	2.26	2.56	11.72	2.10	.98	.64	374.00
42.	Shenbagavalli	880655	.93	5.20	3.60	3.30	13.83	2.70	3.10	12.90	2.20	.98	.50	238.00
43.	Ponnuswamy	790998	.49	4.64	4.70	3.80	16.40	2.98	3.38	11.83	2.04	.87	.74	249.00
44.	Karumbathi	699238	.53	4.40	5.70	3.80	18.00	2.90	3.44	15.70	1.97	.99	.77	367.80
45.	Udayakumar P	394476	.61	4.64	5.70	4.90	21.10	2.53	3.27	22.63	2.00	.96	.77	343.00
46.	Rani V	782418	.59	2.31	5.40	3.80	18.80	2.90	3.37	13.95	1.74	1.04	.59	322.00
47.	Rajeswari	106439	.69	4.06	5.80	3.10	17.78	2.60	3.08	15.58	1.60	.76	.47	478.00
48.	Shova Sinha	936278	.44	3.85	4.80	4.70	19.72	2.69	3.20	15.94	2.14	.50	.37	328.00
49.	Selva Kumari	180539	.42	4.00	4.50	3.70	17.80	2.94	3.35	12.24	2.38	1.70	.77	406.00
50.	Sivagami	133394	.47	4.64	5.00	3.80	19.89	2.46	2.92	15.75	1.32	.60	.50	337.00
51.	Saroj Yadav	833349	.51	2.05	7.69	3.84	26.10	3.07	3.37	8.90	2.04	1.93	1.01	345.00
52.	Jebamani	691869	.37	2.38	4.70	3.50	16.80	2.91	3.46	15.90	2.27	1.41	.78	358.00
53.	Malar	188131	.70	3.43	5.00	4.30	19.50	2.56	3.29	22.19	1.90	.98	.57	269.00
54.	Selvam	122287	.56	2.81	5.57	4.77	21.91	3.26	3.52	7.39	1.91	2.16	1.12	265.00
55.	Jaikishan	802242	.60	2.42	6.60	3.50	19.90	2.50	2.90	13.79	1.29	1.13	.50	400.00
56.	Kannammal	987375	.63	3.41	5.58	4.69	21.90	2.56	3.05	16.07	1.81	1.21	.59	246.00
57.	Rose	254826	.93	5.63	6.50	4.51	20.90	2.70	3.23	16.41	1.70	.83	.61	317.00
58.	Rizwanullah	055663	.54	3.93	5.39	5.02	26.40	3.10	3.48	10.92	2.01	1.80	.69	352.00
59.	Deviakiammal	853702	.47	2.86	5.53	4.24	17.30	3.01	3.66	17.76	1.80	.69	.43	320.00

60.	Ramkumar	858695	.88	2.50	3.98	3.91	18.10	3.16	3.72	15.05	2.20	1.05	.53	334.00
61.	Rajeswari	991737	.77	2.92	4.00	3.60	17.10	2.60	3.12	16.67	2.12	1.12	.60	354.00
62.	Raji	793469	.74	2.62	5.29	2.83	21.20	2.22	2.59	14.29	1.85	1.33	.76	421.00
63.	Boobalan	838975	.72	3.48	5.34	4.95	20.80	3.06	3.48	12.07	2.11	1.85	.71	377.00
64.	Prema	904545	.59	2.14	6.90	6.25	37.78	3.17	3.88	18.30	2.30	2.27	1.29	252.00
65.	Shyamal Patra	803969	.53	2.00	6.20	4.50	23.10	3.56	4.10	13.17	1.48	2.45	1.37	383.00
66.	Vamathi	386556	.45	2.00	6.75	5.20	23.50	3.20	4.18	23.44	1.81	2.43	1.42	373.30
67.	Nila Khatun	812113	.57	5.00	6.00	3.40	19.24	3.00	3.70	18.92	1.90	1.69	1.10	352.00
68.	Deepti	814183	.64	2.80	7.70	5.30	31.80	2.98	3.62	17.68	2.04	1.66	1.09	509.00
69.	Govindaraj	573966	.62	2.81	7.50	5.90	37.30	3.70	4.40	15.91	2.30	1.21	.90	391.00
70.	Veena Devi	812433	.57	4.10	6.60	3.80	21.29	3.30	3.99	17.29	2.25	1.37	.80	357.00
71.	Ananda Paul	953948	.48	2.29	6.00	4.90	24.58	3.84	4.48	14.29	2.37	1.99	1.09	343.40
72.	Uthirakumar	773446	.60	2.65	6.70	5.60	29.50	3.50	4.11	14.84	2.10	2.81	1.36	252.00
73.	Selvi	806969	.76	2.86	6.50	6.00	27.60	2.96	3.86	23.32	1.80	1.95	1.16	456.10
74.	Simson Mochar	795883	.53	4.05	5.30	5.00	22.90	2.98	3.80	21.58	2.37	2.45	1.10	343.00
75.	Harlin Rongha	770812	.10	2.05	7.70	6.00	35.00	3.80	4.42	14.03	2.12	3.10	1.70	457.00
76.	Kalpana	815920	.81	1.28	5.60	3.80	19.40	2.82	3.58	21.23	1.32	1.47	1.10	565.00
77.	Kamatchi	586712	.52	3.13	6.10	5.05	28.17	3.70	4.39	15.72	1.90	2.63	1.22	259.00
78.	Anowar Bibi	789661	.58	1.79	6.30	4.50	24.16	3.50	4.02	12.94	1.30	2.24	1.30	387.00
79.	Stella	601286	.60	5.00	5.10	4.00	18.30	2.90	3.66	20.77	1.30	1.13	.80	370.00
80.	Ramamurthy	423256	.69	1.51	6.00	5.70	25.60	3.55	4.29	17.25	1.87	1.94	1.26	394.40
81.	Samsuddin Ansari	822130	.62	2.14	4.70	4.60	19.20	3.18	4.07	21.87	1.20	2.89	1.70	346.00
82.	Sasipriya	824669	.94	1.88	6.00	5.80	34.90	3.50	4.00	12.50	1.59	2.36	1.48	456.00
83.	Mamata Layek	772526	.89	1.71	6.10	5.70	29.95	4.09	4.40	7.05	1.31	2.42	1.13	248.00
84.	Palani	936065	.58	4.00	7.50	4.40	47.79	4.30	5.10	15.69	1.51	1.60	.89	337.00
85.	Rani A	921834	.56	3.33	7.40	7.20	38.51	5.06	5.50	8.00	1.81	4.11	1.60	250.00
86.	Sarada Devi	356600	.57	3.13	7.80	5.30	33.90	3.70	4.34	14.75	1.60	2.45	.75	290.00
87.	Kapuri Devi	651668	.54	2.44	4.70	4.50	24.50	4.20	4.80	12.50	1.87	2.05	1.00	318.00
88.	Rani	836152	.70	3.13	6.20	4.60	25.48	3.58	4.29	16.55	2.03	2.28	1.17	295.00
89.	Arup Middya	219451	.69	2.86	5.18	4.63	20.42	3.88	4.24	8.49	1.80	2.36	1.28	361.00

90.	Janaki	329307	.51	3.14	6.10	5.50	30.12	3.78	4.10	7.80	2.20	2.60	1.14	326.00
91.	Tapan Dutta	837082	.59	1.79	4.20	4.20	16.90	3.50	3.90	10.26	1.36	2.04	1.07	423.00
92.	Jegan	925961	.77	.50	7.03	7.01	43.10	3.88	4.34	10.60	1.21	2.70	.89	461.00
93.	Nagarani K	803520	.52	2.00	5.60	4.00	23.10	3.50	4.00	12.50	1.41	1.54	.95	388.00
94.	Usha	453241	.86	2.81	8.20	5.54	31.60	3.10	3.98	22.11	.60	1.44	.96	377.00
95.	Mani	054550	.51	4.33	7.30	5.80	31.96	3.58	4.02	10.95	2.03	2.56	1.03	345.00
96.	Jegadeesan	147654	.55	2.56	5.40	4.40	20.79	3.87	4.36	11.24	2.12	3.89	1.39	360.00
97.	Navamani	664841	.70	.28	5.52	5.17	22.90	3.02	3.60	16.11	1.51	1.31	.73	430.00
98.	Rajakumari	807061	.86	2.56	4.70	3.90	14.68	3.10	3.66	15.30	1.85	2.10	1.13	521.00
99.	Poongavanam	629747	.40	1.56	7.90	7.80	56.60	3.91	4.38	10.73	1.26	3.24	.87	465.00
100.	Md Yacob	466714	.47	4.76	4.80	4.30	17.40	3.34	3.86	13.47	2.03	1.76	.85	364.00
101.	Nirmala Maji	711006	.58	2.39	7.20	6.90	45.73	4.20	4.70	10.64	2.37	2.94	.95	244.00
102.	Pushpa Bala	037380	.62	4.64	6.10	5.16	25.70	3.66	4.31	15.08	2.46	2.41	.97	387.00
103.	Kishun Saw	854086	.92	1.74	6.23	6.20	32.20	3.39	3.97	14.61	1.64	3.27	1.79	467.00
104.	Roshin Bauri	851557	.84	2.19	5.02	5.01	24.60	3.42	4.13	17.19	1.47	3.22	1.56	421.00
105.	Sakthivelmuru gan	805006	.55	3.14	5.90	5.42	24.40	4.14	4.66	11.16	1.41	1.97	.88	416.00
106.	Shahabaz Alam	818185	.59	1.43	6.20	4.80	22.85	3.34	3.80	12.11	1.40	1.59	1.13	491.00
107.	Devaki	428989	.62	1.60	7.00	4.50	25.10	3.40	3.90	12.82	1.40	1.41	.98	570.00
108.	Swapan Pal	726332	.61	2.80	8.59	6.70	43.40	4.13	4.54	9.03	1.74	3.14	1.18	271.00
109.	Subramani K	423622	.66	3.71	6.60	5.20	32.10	3.85	4.49	14.25	1.46	3.35	1.19	341.00
110.	Uma	467241	.80	1.90	5.83	4.85	25.20	3.53	3.98	11.31	1.47	2.09	1.08	471.00

	Name	ID	Peak TR Gdt	TRJet area	Trjet percent	TR Severity	TVInflowE velocity	EROA	VC	LVLong	LVEDV	LVESV	LVEF	IVC
1.	Sangeetha	647745	45.00	2.36	19.50	1.00	64.00	3.17	.27	6.38	78.60	32.20	59.03	1.06

2.	Nazeera	267142	80.00	3.45	19.17	1.00	63.00	9.16	.42	7.10	95.00	39.00	58.95	1.51
3.	Krishnakumar	818989	51.00	2.40	18.32	1.00	95.00	15.81	.28	6.72	120.00	47.40	60.50	1.26
4.	Sarath Kumar	190237	21.00	1.32	10.82	1.00	51.00	10.86	.34	6.62	72.00	30.00	58.33	1.18
5.	Zamruth	873457	28.00	2.76	18.65	1.00	60.00	8.32	.41	7.10	86.00	34.00	60.47	1.36
6.	Malarkodi	472714	30.00	3.61	18.90	1.00	81.00	10.12	.33	7.90	108.00	48.00	55.56	1.36
7.	Anbu Kumar	540013	40.90	2.11	13.78	1.00	64.00	6.12	.23	7.22	159.00	109.00	31.45	1.50
8.	Rani P	421394	72.00	3.36	19.53	1.00	76.00	3.58	.31	6.84	89.00	36.00	59.55	2.12
9.	Sulochana	447797	43.50	1.72	11.62	1.00	66.00	5.28	.33	7.17	61.20	23.00	62.42	1.60
10.	Rogini	834512	39.00	3.53	19.94	1.00	51.00	3.88	.22	6.78	107.50	47.40	55.91	1.47
11.	Senthil S	817686	30.67	1.56	13.93	1.00	70.00	5.04	.20	8.80	73.40	31.40	57.22	1.56
12.	Valli	829150	20.00	1.20	14.41	1.00	73.00	7.30	.20	5.81	67.10	28.50	57.53	1.50
13.	Nurul Hoda	789507	66.00	3.98	19.80	1.00	93.00	3.08	.20	6.10	114.40	49.50	56.73	2.00
14.	Kumari Bai	718782	48.00	4.06	19.90	1.00	43.00	9.87	.18	5.94	67.90	27.50	59.50	1.21
15.	Shamim Akhtar	801553	27.00	3.60	19.89	1.00	68.60	6.86	.20	6.70	105.40	43.60	58.63	1.56
16.	Kothandan M	201397	30.00	3.00	19.87	1.00	58.00	5.15	.17	7.82	263.70	180.00	31.74	1.50
17.	Narendranath	811291	26.00	2.48	17.97	1.00	71.90	7.24	.23	6.50	73.40	31.90	56.54	1.67
18.	Vijaya	097264	51.00	1.56	9.69	1.00	116.00	12.45	.26	7.16	79.00	32.00	59.49	1.65
19.	Shantha	507139	27.00	1.15	7.77	1.00	75.00	4.20	.16	5.30	84.00	32.60	61.19	1.11
20.	Govindammal	589740	26.00	1.21	6.80	1.00	48.90	9.87	.25	5.50	98.60	40.90	58.52	1.30
21.	Arun Kumar	840116	27.00	2.45	19.87	1.00	64.00	7.18	.28	6.96	83.50	35.60	57.37	1.25
22.	ShantiRanjan	839059	38.00	2.10	18.92	1.00	59.00	3.31	.26	6.97	71.30	26.50	62.83	1.06
23.	Bula Kumar	851332	39.00	2.15	12.50	1.00	80.90	12.05	.29	8.08	179.70	97.30	45.85	2.03
24.	Subash	945209	28.00	1.20	13.22	1.00	62.70	2.43	.29	7.83	33.60	12.10	63.99	1.44
25.	Palani	757166	34.00	3.26	19.52	1.00	71.60	11.69	.33	6.61	61.20	24.60	59.80	1.25
26.	Shenbagam	854585	30.00	1.63	15.67	1.00	53.30	4.15	.35	5.60	65.90	29.60	55.08	1.30
27.	Mathiur Rahman	854138	46.00	2.59	18.11	1.00	69.60	10.01	.25	7.50	121.60	47.80	60.69	1.83
28.	unnamalai	485997	27.00	1.60	12.50	1.00	66.60	9.46	.22	6.26	92.00	39.20	57.39	1.06
29.	Parimala	971158	34.00	2.29	15.47	1.00	50.30	14.12	.16	5.01	87.70	37.90	56.78	1.39
30.	Prabha	057218	44.00	2.00	17.24	1.00	47.90	7.96	.30	7.07	50.20	21.20	57.77	1.40
31.	Adi Narayan	855044	42.00	3.84	18.20	1.00	79.00	3.27	.27	6.04	112.80	83.10	26.33	1.21

32.	Govindamma	291495	38.30	3.21	18.77	1.00	61.00	4.91	.27	7.78	98.00	41.00	58.16	1.40
33.	Tamilarasi	118763	42.00	3.17	18.87	1.00	83.40	1.96	.21	6.13	88.60	38.00	57.11	2.17
34.	Sudhir	814510	39.00	7.12	33.02	2.00	89.00	15.65	.63	7.27	113.00	51.00	54.87	2.03
35.	Dhanabackiam	647567	52.80	7.40	39.36	2.00	93.20	15.55	.68	6.28	99.80	41.00	58.92	2.27
36.	Lakshmi	806089	23.80	7.15	29.42	2.00	79.00	21.45	.46	8.04	112.80	47.40	57.98	1.74
37.	Selvakumar	714070	39.00	7.10	39.66	2.00	95.00	12.05	.67	9.00	207.00	78.60	62.03	1.39
38.	Vijayakanth	809117	25.00	5.34	37.87	2.00	68.00	11.27	.51	8.20	224.40	92.40	58.82	1.41
39.	Lalitha	367403	49.00	8.03	39.56	2.00	91.00	31.10	.66	7.40	165.00	127.00	23.03	1.56
40.	Neelammal	797740	98.10	6.50	35.91	2.00	70.00	20.19	.68	5.80	41.30	18.90	54.24	1.90
41.	Mamata Mondal	020388	56.00	5.60	39.44	2.00	71.00	10.84	.51	6.68	93.00	38.00	59.14	1.21
42.	Shenbagavalli	880655	23.00	5.39	38.97	2.00	60.00	8.85	.51	6.61	99.00	41.00	58.59	1.70
43.	Ponnuswamy	790998	25.00	6.10	37.20	2.00	51.00	33.85	.51	6.30	120.50	72.10	40.17	1.40
44.	Karumbathi	699238	54.10	6.58	36.56	2.00	91.00	15.34	.52	7.30	88.00	32.00	63.64	1.21
45.	Udayakumar P	394476	47.00	8.07	38.25	2.00	70.00	15.85	.62	6.87	296.60	107.00	63.92	2.03
46.	Rani V	782418	41.00	5.60	29.79	2.00	46.00	10.60	.52	6.80	87.50	33.20	62.06	1.40
47.	Rajeswari	106439	91.00	7.10	39.93	2.00	106.00	12.70	.39	6.35	105.40	42.50	59.68	1.52
48.	Shova Sinha	936278	43.00	5.71	28.96	2.00	70.00	17.20	.56	5.95	77.70	34.20	55.98	1.46
49.	Selva Kumari	180539	66.00	7.08	39.78	2.00	93.00	12.89	.65	8.02	96.30	42.50	55.87	1.66
50.	Sivagami	133394	45.00	7.86	39.52	2.00	90.00	10.77	.57	5.50	95.00	33.00	65.26	1.50
51.	Saroj Yadav	833349	48.00	5.40	20.69	2.00	88.00	15.17	.55	5.97	101.90	42.50	58.29	1.81
52.	Jebamani	691869	51.00	6.36	37.86	2.00	75.00	10.00	.55	6.64	73.40	29.60	59.67	1.32
53.	Malar	188131	28.90	7.46	38.26	2.00	61.00	10.94	.58	6.01	94.90	41.70	56.06	1.17
54.	Selvam	122287	28.00	7.61	34.73	2.00	84.00	29.91	.61	8.01	175.90	115.50	34.34	1.67
55.	Jaikishan	802242	64.00	7.75	38.94	2.00	65.00	8.95	.61	7.00	56.30	22.50	60.04	2.10
56.	Kannammal	987375	24.00	5.86	26.76	2.00	84.00	16.65	.51	7.76	62.00	27.00	56.45	1.56
57.	Rose	254826	40.00	5.26	25.17	2.00	89.00	15.88	.53	6.05	113.90	50.50	55.66	1.36
58.	Rizwanullah	055663	50.00	9.00	34.09	2.00	60.70	19.14	.33	8.72	128.40	72.90	43.22	2.07
59.	Deviakiammal	853702	41.00	6.35	36.71	2.00	53.00	11.39	.56	6.31	75.10	32.80	56.32	2.12
60.	Ramkumar	858695	45.00	5.68	31.38	2.00	77.00	11.75	.53	6.40	324.70	160.70	50.51	1.45
61.	Rajeswari	991737	50.00	6.60	38.60	2.00	68.60	15.94	.51	6.09	57.20	25.60	55.24	1.32

62.	Raji	793469	71.00	8.10	38.21	2.00	90.80	16.55	.59	5.80	88.00	36.00	59.09	2.01
63.	Boobalan	838975	57.00	5.31	25.53	2.00	106.00	16.10	.56	7.20	83.10	35.00	57.88	2.04
64.	Prema	904545	25.00	18.49	48.94	3.00	110.00	66.87	1.06	8.60	96.00	41.50	56.77	2.74
65.	Shyamal Patra	803969	58.60	17.93	77.62	3.00	79.00	43.70	.75	7.75	152.00	110.00	27.63	2.40
66.	Vamathi	386556	55.70	20.28	86.30	3.00	141.00	42.93	.81	7.40	62.00	24.40	60.65	1.86
67.	Nila Khatun	812113	49.00	12.01	62.42	3.00	96.00	45.09	.85	6.73	90.50	39.90	55.91	2.10
68.	Deepti	814183	104.00	19.90	62.58	3.00	112.00	47.69	.11	6.98	43.20	17.90	58.56	2.25
69.	Govindaraj	573966	61.00	21.87	58.63	3.00	95.00	40.59	.90	7.60	202.00	86.00	57.43	1.80
70.	Veena Devi	812433	51.00	12.78	60.03	3.00	118.00	40.09	.97	4.90	94.40	40.30	57.31	2.30
71.	Ananda Paul	953948	47.20	11.50	46.79	3.00	96.00	43.64	.71	5.60	39.10	16.00	59.08	2.62
72.	Uthirakumar	773446	25.00	21.80	73.90	3.00	90.00	46.72	1.10	7.90	61.20	27.00	55.88	1.90
73.	Selvi	806969	83.20	13.82	50.07	3.00	101.00	40.10	.82	6.50	54.10	23.00	57.49	1.17
74.	Simson Mochar	795883	47.10	13.20	57.64	3.00	62.00	41.73	.91	7.76	242.00	180.00	25.62	2.70
75.	Harlin Rongha	770812	83.50	19.42	55.49	3.00	130.00	41.50	.12	7.88	74.20	32.20	56.60	2.62
76.	Kalpana	815920	127.00	14.20	73.20	3.00	129.00	41.44	.83	6.65	47.40	21.40	54.85	1.60
77.	Kamatchi	586712	26.85	12.82	45.51	3.00	110.00	46.41	.86	7.32	73.00	29.00	60.27	1.90
78.	Anowar Bibi	789661	60.00	15.30	63.33	3.00	130.00	44.19	.71	6.70	67.10	29.60	55.89	1.90
79.	Stella	601286	54.60	12.40	67.76	3.00	124.00	53.35	.98	6.80	74.20	29.00	60.92	1.90
80.	Ramamurthy	423256	62.20	16.53	64.57	3.00	103.00	48.09	.84	7.70	111.00	62.00	44.14	1.72
81.	Samsuddin Ansari	822130	47.80	12.63	65.78	3.00	114.00	45.30	.74	7.29	104.40	62.00	40.61	1.77
82.	Sasipriya	824669	83.00	26.30	75.36	3.00	102.00	40.76	.71	7.80	50.90	18.10	64.44	2.46
83.	Mamata Layek	772526	24.60	19.84	66.24	3.00	134.00	63.21	.98	7.82	46.40	18.30	60.56	2.60
84.	Palani	936065	45.00	21.94	45.91	3.00	64.00	52.41	.82	7.90	118.80	56.60	52.36	1.70
85.	Rani A	921834	27.00	25.27	65.62	3.00	144.00	76.15	1.00	7.34	83.10	32.60	60.77	3.00
86.	Sarada Devi	356600	33.75	25.85	76.25	3.00	102.00	41.65	.82	5.96	116.10	51.20	55.90	1.06
87.	Kapuri Devi	651668	40.50	16.75	68.37	3.00	100.00	56.08	.96	7.97	128.40	54.10	57.87	1.56
88.	Rani	836152	35.00	17.89	70.21	3.00	117.00	41.98	.80	7.78	118.80	79.00	33.50	1.99
89.	Arup Middya	219451	52.00	12.26	60.04	3.00	101.00	40.58	.78	7.19	246.50	162.00	34.28	2.03
90.	Janaki	329307	42.40	22.13	73.47	3.00	118.00	49.16	.91	7.08	79.80	32.50	59.27	1.65
91.	Tapan Dutta	837082	71.00	10.40	61.54	3.00	103.00	40.42	.76	7.20	65.50	25.80	60.61	2.04

92.	Jegan	925961	85.00	18.30	42.46	3.00	86.00	40.32	.76	7.30	66.10	28.30	57.19	2.13
93.	Nagarani K	803520	60.00	15.20	65.80	3.00	93.00	42.22	.70	7.16	89.40	36.70	58.95	2.68
94.	Usha	453241	57.00	13.90	43.99	3.00	96.00	43.45	.79	5.89	67.10	32.30	51.86	2.16
95.	Mani	054550	41.00	24.03	75.19	3.00	146.00	53.87	.88	5.91	72.10	28.50	60.47	2.90
96.	Jegadeesan	147654	51.90	18.42	88.60	3.00	136.00	50.58	.97	7.31	104.90	39.40	62.44	2.27
97.	Navamani	664841	74.00	11.00	48.03	3.00	52.00	40.10	.60	4.31	70.00	29.60	57.71	2.27
98.	Rajakumari	807061	131.00	11.50	78.34	3.00	109.00	46.59	.72	5.50	35.00	12.70	63.71	1.30
99.	Poongavanam	629747	86.00	27.70	48.94	3.00	131.00	40.79	.82	5.98	55.50	23.10	58.38	2.08
100.	Md Yacob	466714	52.90	10.36	59.54	3.00	72.00	44.03	.70	7.10	115.50	48.80	57.75	2.25
101.	Nirmala Maji	711006	23.80	21.30	46.58	3.00	99.00	49.50	.99	7.42	97.30	41.00	57.86	2.30
102.	Pushpa Bala	037380	60.00	13.20	51.36	3.00	83.30	47.05	.72	8.30	96.80	46.80	51.65	2.12
103.	Kishun Saw	854086	87.00	27.00	83.85	3.00	125.00	44.82	.82	5.93	65.50	26.50	59.54	2.03
104.	Roshin Bauri	851557	71.00	15.20	61.79	3.00	101.00	42.36	.74	5.02	84.20	35.20	58.19	2.22
105.	Sakthivelmurugan	805006	69.00	13.10	53.69	3.00	108.00	40.92	.87	6.36	198.00	69.20	65.05	2.49
106.	Shahabaz Alam	818185	96.30	14.82	64.86	3.00	84.00	40.21	.90	5.96	62.70	25.80	58.85	1.50
107.	Devaki	428989	130.00	23.20	92.43	3.00	114.00	40.76	.88	6.83	87.70	37.90	56.78	1.79
108.	Swapan Pal	726332	29.00	18.10	41.71	3.00	63.00	55.30	.86	4.88	48.50	20.60	57.53	2.64
109.	Subramani K	423622	46.50	24.60	76.64	3.00	94.00	43.95	.96	7.29	136.00	77.00	43.38	3.02
110.	Uma	467241	89.00	14.10	55.95	3.00	97.00	40.27	.72	7.80	102.90	55.50	46.06	1.51

	Name	ID	IVC Collapse	RAP	PASP	NYHA	ESSI	ESEI	EDEI	LVSI	Heart RATE	V	Murmur	Edema	Ascites	Pulsatile liver
1.	Sangeetha	647745	1.00	3.00	48.00	2.00	1.54	1.81	1.73	5.05	95.00	0	0	0	0	0
2.	Nazeera	267142	1.00	3.00	83.00	2.00	2.16	1.92	2.00	5.49	80.00	0	1	0	0	0
3.	Krishnakumar	818989	1.00	3.00	54.00	1.00	1.20	2.04	2.08	7.05	130.00	0	0	0	0	0

4.	Sarath Kumar	190237	1.00	3.00	24.00	1.00	1.78	1.83	1.91	4.53	89.00	0	0	0	0	0
5.	Zamruth	873457	1.00	3.00	31.00	2.00	1.15	1.75	1.92	4.79	95.00	0	0	0	0	0
6.	Malarkodi	472714	1.00	3.00	33.00	2.00	1.66	1.87	1.91	6.08	112.00	0	0	0	0	0
7.	Anbu Kumar	540013	1.00	3.00	43.90	2.00	1.61	1.91	2.03	15.10	86.00	0	0	0	0	0
8.	Rani P	421394	1.00	8.00	80.00	2.00	1.29	1.93	2.23	5.26	91.00	0	1	0	0	0
9.	Sulochana	447797	1.00	3.00	46.50	2.00	2.40	1.82	2.09	3.21	80.00	0	0	0	0	0
10.	Rogini	834512	1.00	3.00	42.00	2.00	1.50	1.96	2.33	6.99	52.00	0	0	0	0	0
11.	Senthil S	817686	1.00	3.00	33.67	2.00	1.49	1.92	1.98	3.57	90.00	0	0	0	0	0
12.	Valli	829150	1.00	3.00	23.00	2.00	1.32	1.92	1.96	4.91	68.00	0	0	0	0	0
13.	Nurul Hoda	789507	.00	8.00	74.00	2.00	1.74	2.05	2.11	8.11	9.00	0	0	0	0	0
14.	Kumari Bai	718782	1.00	3.00	51.00	2.00	1.57	1.73	1.93	4.63	82.00	0	0	0	0	0
15.	Shamim Akhtar	801553	1.00	3.00	30.00	1.00	1.53	1.89	1.90	6.51	63.00	0	0	0	0	0
16.	Kothandan M	201397	1.00	3.00	33.00	2.00	1.24	1.95	1.90	23.02	73.00	0	0	0	0	0
17.	Narendranath	811291	.00	8.00	34.00	2.00	1.69	1.93	1.99	4.91	96.00	0	1	0	0	0
18.	Vijaya	097264	.00	8.00	59.00	2.00	2.43	1.93	1.96	4.47	96.00	0	0	0	0	0
19.	Shantha	507139	1.00	3.00	30.00	2.00	1.39	1.85	1.92	6.15	76.00	0	0	0	0	0
20.	Govindammal	589740	1.00	3.00	29.00	2.00	1.72	2.06	2.11	7.44	72.00	0	0	0	0	0
21.	Arun Kumar	840116	1.00	3.00	30.00	1.00	1.93	1.73	1.66	5.11	81.00	0	0	0	0	0
22.	ShantiRanjan	839059	1.00	3.00	41.00	2.00	1.14	1.90	1.79	3.80	83.00	0	0	0	0	0
23.	Bula Kumar	851332	1.00	8.00	47.00	2.00	1.23	1.93	1.86	12.04	101.00	0	1	0	0	0
24.	Subash	945209	1.00	3.00	31.00	2.00	1.37	1.99	1.94	1.55	83.00	0	0	0	0	0
25.	Palani	757166	1.00	3.00	37.00	2.00	1.46	1.99	2.10	3.72	90.00	0	0	0	0	0
26.	Shenbagam	854585	1.00	3.00	33.00	2.00	1.87	1.58	1.58	5.29	89.00	0	0	0	0	0
27.	Mathiur Rahman	854138	.00	8.00	54.00	2.00	1.58	2.03	1.98	6.37	76.00	0	0	0	0	0
28.	unnamalai	485997	1.00	3.00	30.00	2.00	1.75	1.90	1.93	6.26	62.00	0	0	0	0	0
29.	Parimala	971158	1.00	3.00	37.00	2.00	1.17	1.97	1.95	7.56	90.00	0	0	0	0	0
30.	Prabha	057218	1.00	3.00	47.00	2.00	1.30	1.92	1.98	3.00	73.00	0	0	0	0	0
31.	Adi Narayan	855044	1.00	3.00	45.00	2.00	1.73	1.83	2.23	13.76	113.00	0	0	0	0	0
32.	Govindamma	291495	1.00	3.00	41.30	2.00	1.49	1.94	1.98	5.27	69.00	0	0	0	0	0
33.	Tamilarasi	118763	1.00	8.00	50.00	2.00	1.91	1.90	1.90	6.20	71.00	0	0	0	0	0

34.	Sudhir	814510	.00	8.00	47.00	2.00	1.50	2.10	2.04	7.02	57.00	1	0	0	0	0
35.	Dhanabackiam	647567	.00	15.00	67.80	2.00	2.50	2.11	2.03	6.53	105.00	1	1	0	0	1
36.	Lakshmi	806089	.00	8.00	31.80	2.00	1.41	1.94	2.02	5.90	87.00	0	0	0	0	0
37.	Selvakumar	714070	1.00	3.00	42.00	2.00	1.41	2.25	2.48	8.73	71.00	1	0	0	0	0
38.	Vijayakanth	809117	1.00	3.00	28.00	2.00	1.22	2.05	2.02	11.27	80.00	0	1	0	0	0
39.	Lalitha	367403	.00	8.00	57.00	2.00	1.92	2.17	2.33	17.16	106.00	1	1	0	1	0
40.	Neelammal	797740	.00	8.00	106.10	2.00	2.78	1.97	1.95	3.26	90.00	0	0	0	0	0
41.	Mamata Mondal	020388	1.00	3.00	59.00	2.00	1.95	2.07	2.10	5.69	96.00	0	0	0	0	0
42.	Shenbagavalli	880655	1.00	3.00	26.00	2.00	2.20	2.13	2.04	6.20	92.00	0	0	0	0	0
43.	Ponnuswamy	790998	1.00	3.00	28.00	2.00	1.97	2.10	2.12	11.44	96.00	0	0	0	0	0
44.	Karumbathi	699238	1.00	3.00	57.10	2.00	2.23	2.16	1.93	4.38	70.00	0	0	0	0	0
45.	Udayakumar P	394476	.00	8.00	55.00	2.00	2.01	2.21	2.40	15.57	115.00	0	0	0	0	0
46.	Rani V	782418	1.00	3.00	44.00	2.00	1.51	1.99	1.98	4.88	78.00	0	0	0	0	0
47.	Rajeswari	106439	1.00	3.00	94.00	2.00	1.86	2.00	1.92	6.69	88.00	0	1	0	0	0
48.	Shova Sinha	936278	1.00	3.00	46.00	2.00	1.25	2.05	2.05	5.75	106.00	0	0	0	0	0
49.	Selva Kumari	180539	.00	8.00	74.00	2.00	1.78	2.02	2.09	5.30	96.00	0	0	0	0	0
50.	Sivagami	133394	1.00	3.00	48.00	2.00	1.33	1.98	1.99	6.00	106.00	0	1	0	0	0
51.	Saroj Yadav	833349	.00	8.00	55.00	2.00	1.43	2.11	2.39	7.12	63.00	0	0	0	0	0
52.	Jebamani	691869	1.00	3.00	54.00	2.00	1.50	1.97	2.11	4.46	67.00	0	0	0	0	0
53.	Malar	188131	1.00	3.00	31.90	2.00	1.53	2.27	2.42	6.94	78.00	0	0	0	0	0
54.	Selvam	122287	.00	8.00	36.00	2.00	2.43	2.23	2.28	14.42	108.00	0	0	0	0	0
55.	Jaikishan	802242	.00	8.00	72.00	2.00	1.66	2.17	1.91	3.21	101.00	0	0	0	0	0
56.	Kannammal	987375	.00	8.00	32.00	2.00	1.41	1.93	1.98	3.48	88.00	0	0	0	0	0
57.	Rose	254826	1.00	3.00	43.00	2.00	2.04	2.03	1.99	8.35	129.00	0	0	0	0	0
58.	Rizwanullah	055663	1.00	8.00	58.00	1.00	1.96	1.96	1.96	8.36	106.00	0	0	0	0	0
59.	Deviakiammal	853702	1.00	8.00	49.00	2.00	1.73	2.00	1.96	5.20	108.00	0	0	0	0	0
60.	Ramkumar	858695	1.00	3.00	48.00	2.00	1.99	2.20	2.49	25.11	98.00	0	0	0	0	0
61.	Rajeswari	991737	1.00	3.00	53.00	2.00	1.37	1.92	1.99	4.20	77.00	0	0	0	0	0
62.	Raji	793469	.00	8.00	79.00	2.00	1.54	2.20	2.21	6.21	110.00	0	0	0	0	0
63.	Boobalan	838975	.00	8.00	65.00	2.00	2.48	2.20	2.16	4.86	101.00	0	0	0	0	0

64.	Prema	904545	.00	15.00	40.00	2.00	2.19	2.17	2.09	4.83	70.00	1	1	0	0	0
65.	Shyamal Patra	803969	.00	15.00	73.60	2.00	2.86	2.19	2.26	14.19	100.00	1	0	0	0	0
66.	Vamathi	386556	.00	8.00	63.70	2.00	2.00	2.21	2.52	3.30	116.00	1	1	0	0	1
67.	Nila Khatun	812113	.00	8.00	57.00	2.00	2.14	2.21	2.50	5.93	127.00	0	0	0	0	0
68.	Deepti	814183	.00	15.00	119.00	3.00	2.90	2.11	2.11	2.56	72.00	1	1	0	1	0
69.	Govindaraj	573966	1.00	3.00	64.00	3.00	1.52	2.30	2.27	11.32	89.00	1	1	0	0	1
70.	Veena Devi	812433	.00	15.00	66.00	2.00	1.71	2.59	2.78	8.22	63.00	1	1	0	0	1
71.	Ananda Paul	953948	.00	15.00	62.20	2.00	3.17	2.32	2.27	2.86	70.00	1	0	0	0	1
72.	Uthirakumar	773446	.00	8.00	33.00	2.00	2.19	2.29	2.33	3.42	80.00	1	1	0	0	0
73.	Selvi	806969	1.00	3.00	86.20	3.00	2.89	2.31	2.25	3.54	96.00	1	0	0	0	0
74.	Simson Mochar	795883	.00	15.00	62.10	2.00	2.58	2.32	2.36	23.20	98.00	1	1	0	0	0
75.	Harlin Rongha	770812	.00	15.00	98.50	2.00	3.10	2.10	2.08	4.09	110.00	1	1	0	0	1
76.	Kalpana	815920	1.00	3.00	130.00	2.00	2.83	2.09	2.10	3.22	95.00	0	1	1	0	0
77.	Kamatchi	586712	.00	8.00	34.85	2.00	2.25	2.21	2.28	3.96	112.00	0	0	1	0	0
78.	Anowar Bibi	789661	1.00	3.00	63.00	2.00	3.57	2.26	2.12	4.42	73.00	1	1	0	0	1
79.	Stella	601286	.00	8.00	62.60	2.00	2.11	2.25	2.65	4.26	134.00	1	1	0	0	1
80.	Ramamurthy	423256	1.00	3.00	65.20	2.00	2.27	2.14	2.07	8.05	81.00	1	1	0	0	0
81.	Samsuddin Ansari	822130	.00	8.00	55.80	2.00	1.93	2.31	2.05	8.50	60.00	1	1	0	0	0
82.	Sasipriya	824669	.00	15.00	98.00	3.00	3.61	2.12	2.11	2.32	86.00	1	1	0	0	1
83.	Mamata Layek	772526	.00	15.00	39.60	2.00	2.18	2.18	2.22	2.34	93.00	0	1	0	0	0
84.	Palani	936065	1.00	3.00	48.00	2.00	1.72	2.64	2.45	7.16	77.00	0	1	0	0	0
85.	Rani A	921834	.00	15.00	42.00	2.00	3.48	2.62	2.38	4.44	70.00	1	1	1	0	1
86.	Sarada Devi	356600	1.00	3.00	36.75	2.00	1.79	2.48	2.38	8.59	103.00	1	1	0	0	0
87.	Kapuri Devi	651668	.00	8.00	48.50	2.00	1.69	2.78	2.81	6.79	88.00	1	1	0	1	0
88.	Rani	836152	1.00	3.00	38.00	2.00	1.63	2.24	2.31	10.15	93.00	1	1	0	1	0
89.	Arup Middya	219451	1.00	3.00	55.00	2.00	2.83	2.21	2.19	22.53	81.00	0	1	0	0	0
90.	Janaki	329307	1.00	3.00	45.40	2.00	2.08	2.22	2.34	4.59	75.00	1	1	1	1	1
91.	Tapan Dutta	837082	.00	8.00	79.00	2.00	2.61	2.18	2.15	3.58	119.00	1	0	1	1	1
92.	Jegan	925961	.00	15.00	100.00	2.00	6.04	2.16	2.28	3.88	63.00	0	1	0	0	1
93.	Nagarani K	803520	.00	15.00	75.00	2.00	1.68	2.36	2.33	5.13	104.00	1	1	0	0	0

94.	Usha	453241	1.00	8.00	65.00	2.00	1.76	2.20	2.20	5.48	64.00	0	1	0	0	1
95.	Mani	054550	.00	15.00	56.00	2.00	2.61	2.25	2.15	4.82	88.00	1	0	0	0	1
96.	Jegadeesan	147654	.00	15.00	66.90	2.00	2.14	2.12	2.13	5.39	94.00	1	1	0	0	1
97.	Navamani	664841	.00	15.00	89.00	2.00	2.03	2.12	2.08	6.87	80.00	1	0	0	0	0
98.	Rajakumari	807061	1.00	3.00	134.00	2.00	2.91	2.03	1.98	2.31	96.00	1	0	0	0	0
99.	Poongavanam	629747	1.00	3.00	89.00	2.00	1.88	2.25	2.34	3.86	87.00	1	1	0	0	1
100.	Md Yacob	466714	1.00	8.00	60.90	2.00	1.70	2.31	2.25	6.87	86.00	0	1	0	0	0
101.	Nirmala Maji	711006	1.00	8.00	31.80	2.00	2.68	2.20	2.04	5.53	85.00	1	1	0	0	0
102.	Pushpa Bala	037380	.00	15.00	75.00	2.00	1.97	2.63	3.33	5.64	66.00	1	1	0	0	0
103.	Kishun Saw	854086	.00	8.00	95.00	2.00	4.11	2.08	2.08	4.47	60.00	1	1	0	0	1
104.	Roshin Bauri	851557	.00	15.00	86.00	2.00	3.40	2.08	2.05	7.01	105.00	0	1	0	0	0
105.	Sakthivelmuru gan	805006	.00	15.00	84.00	2.00	2.30	3.05	2.90	10.88	108.00	0	0	0	0	0
106.	Shahabaz Alam	818185	1.00	3.00	99.30	2.00	4.40	2.31	2.34	4.33	98.00	1	1	0	0	0
107.	Devaki	428989	.00	8.00	138.00	2.00	2.11	2.28	2.27	5.55	105.00	1	1	0	0	0
108.	Swapan Pal	726332	.00	15.00	44.00	2.00	2.39	2.14	2.03	4.22	89.00	1	1	0	0	0
109.	Subramani K	423622	.00	15.00	61.50	2.00	2.31	2.19	2.12	10.56	123.00	1	1	0	0	0
110.	Uma	467241	1.00	3.00	92.00	2.00	2.82	2.23	2.23	7.12	84.00	1	1	0	0	0

	Name	ID	Sea saw che st	diure tics	Dig oxi n	bet abl ock ers	A C E I	A R B	C C B	DX	Anteri or angle	Septal angle	Poster ior angle	Sept olat eral	Ante ropo ster ior	TA Area	TA Perim eter	INDE X TAS	INDEX TAD
1.	Sangeetha	647745	0	1	1	1	0	0	0	1	14.30	26.20	15.40	3.00	2.70	6.50	8.96	1.72	2.09
2.	Nazeera	267142	0	1	1	0	0	0	0	4	18.50	28.50	19.40	3.20	3.00	8.18	10.20	2.03	2.30
3.	Krishnakumar	818989	0	1	0	0	1	0	0	1	19.00	24.00	12.50	2.70	2.40	5.10	8.10	1.76	2.37
4.	Sarath Kumar	190237	0	1	1	1	1	0	0	1	21.60	24.00	17.80	2.70	2.40	4.80	7.70	1.49	1.69
5.	Zamruth	873457	0	0	0	1	0	0	1	1	19.10	26.40	18.40	3.50	3.10	8.43	10.20	1.64	2.14

6.	Malarkodi	472714	0	1	1	0	0	0	1	1	10.30	12.30	12.50	3.30	2.90	7.70	9.75	1.66	1.97
7.	Anbu Kumar	540013	0	1	1	1	0	0	0	2	21.20	23.20	22.40	2.80	2.50	5.70	8.40	1.74	1.97
8.	Rani P	421394	1	1	1	0	1	0	1	1	5.80	12.40	7.50	3.00	2.70	6.00	8.70	1.40	1.78
9.	Sulochana	447797	0	1	1	0	0	0	0	4	20.10	22.50	21.60	3.00	2.60	6.20	8.90	1.98	2.28
10.	Rogini	834512	0	1	1	0	0	0	0	1	11.70	18.40	15.30	3.30	3.00	7.92	9.90	2.03	2.55
11.	Senthil S	817686	0	1	0	1	0	0	0	1	8.20	16.30	13.80	3.20	2.90	7.42	9.60	1.66	2.06
12.	Valli	829150	0	0	0	0	0	0	0	1	10.70	14.70	14.30	2.70	2.60	5.62	8.40	1.42	1.64
13.	Nurul Hoda	789507	0	1	0	0	0	0	1	6	18.40	24.60	23.20	3.20	3.00	7.90	9.80	1.31	1.53
14.	Kumari Bai	718782	0	1	1	0	0	0	0	1	11.30	14.30	13.90	3.20	2.90	7.50	9.60	1.65	2.10
15.	Shamim Akhtar	801553	0	0	0	0	0	0	0	1	15.80	16.00	15.80	3.10	2.70	6.80	9.30	1.18	1.48
16.	Kothandan M	201397	0	1	1	1	0	1	0	2	9.40	10.60	10.40	2.80	2.60	5.62	8.50	1.49	1.69
17.	Narendranath	811291	0	0	0	0	0	0	0	7	21.00	23.00	22.70	3.50	3.20	9.75	11.20	2.10	2.33
18.	Vijaya	097264	0	1	0	1	0	0	0	1	7.20	12.10	10.10	3.20	2.90	7.40	9.60	2.10	2.36
19.	Shantha	507139	0	0	0	0	0	0	0	1	10.50	11.90	11.40	3.10	2.80	7.00	9.30	1.77	2.00
20.	Govindammal	589740	0	1	1	0	0	1	0	1	7.40	13.40	13.00	3.20	2.80	7.20	9.50	1.65	1.85
21.	Arun Kumar	840116	0	1	0	1	0	0	0	1	12.20	16.20	19.80	3.30	3.00	7.92	9.90	1.67	2.04
22.	ShantiRanjan	839059	0	1	1	1	1	0	0	1	24.80	27.30	23.40	3.00	2.70	6.50	9.00	1.51	1.78
23.	Bula Kumar	851332	0	1	0	0	1	0	0	1	12.10	15.00	11.20	2.95	2.60	6.10	8.70	1.92	2.36
24.	Subash	945209	0	1	1	0	0	0	0	2	7.00	8.00	7.60	3.40	3.10	8.45	10.30	2.08	2.46
25.	Palani	757166	0	1	0	0	1	0	0	6	13.60	17.10	16.00	3.30	3.00	8.10	9.90	2.35	2.68
26.	Shenbagam	854585	0	0	0	0	0	0	0	1	15.00	18.00	16.00	3.00	2.80	6.72	9.20	1.80	2.00
27.	Mathiur Rahman	854138	0	1	1	0	0	0	1	1	15.00	26.00	20.30	3.40	3.10	8.43	10.30	1.43	1.86
28.	unnamalai	485997	0	0	0	1	0	0	0	1	16.00	23.00	20.50	2.90	2.60	6.10	8.70	1.36	1.62
29.	Parimala	971158	0	1	0	1	0	0	0	1	15.00	19.00	17.00	3.30	2.90	7.70	10.00	1.62	1.78
30.	Prabha	057218	0	1	1	0	0	0	0	1	13.10	25.00	22.40	2.80	2.40	5.40	8.30	1.46	1.84
31.	Adi Narayan	855044	0	1	1	1	1	0	0	2	14.10	22.10	19.00	3.40	3.10	8.40	10.20	1.99	2.29
32.	Govindamma	291495	0	1	0	1	0	0	0	1	25.10	32.50	19.20	3.50	3.30	9.10	10.90	1.54	1.72
33.	Tamilarasi	118763	0	1	0	1	0	0	0	1	19.40	28.10	24.90	2.90	2.70	6.30	9.20	1.48	1.68
34.	Sudhir	814510	0	0	0	0	0	0	1	1	19.30	25.60	22.30	3.10	3.60	8.65	10.40	1.80	2.34
35.	Dhanabackiam	647567	1	1	1	0	0	0	1	1	13.10	22.30	16.60	2.90	3.20	7.50	9.60	1.84	2.17

36.	Lakshmi	806089	0	1	1	0	0	0	1	1	23.00	23.00	25.90	2.90	3.20	7.20	9.50	2.17	2.56
37.	Selvakumar	714070	1	1	0	1	0	1	0	1	16.00	27.00	22.80	3.00	3.20	7.45	9.60	1.75	1.97
38.	Vijayakanth	809117	1	1	1	0	0	0	0	1	26.00	27.80	21.20	3.10	3.40	8.45	10.30	1.81	2.06
39.	Lalitha	367403	1	1	1	1	1	0	0	2	23.70	30.70	30.90	3.20	3.50	9.10	11.00	2.17	2.53
40.	Neelammal	797740	1	1	1	0	0	0	0	4	32.00	44.70	42.00	3.25	3.50	8.70	10.40	2.14	2.60
41.	Mamata Mondal	020388	0	1	1	0	0	0	0	1	18.00	26.10	22.10	2.70	2.90	6.10	8.70	1.85	2.10
42.	Shenbagavalli	880655	0	0	1	0	1	0	0	6	14.80	21.30	17.60	3.10	3.30	7.80	9.80	1.89	2.17
43.	Ponnuswamy	790998	0	1	0	0	1	0	1	3	19.40	22.20	16.70	3.20	3.40	8.15	10.10	1.95	2.21
44.	Karumbathi	699238	0	1	1	1	0	0	0	1	29.40	36.90	30.80	3.50	3.60	9.50	10.90	1.76	2.08
45.	Udayakumar P	394476	1	1	1	0	1	0	1	1	33.60	35.60	31.60	3.20	3.50	8.95	10.60	1.57	2.03
46.	Rani V	782418	0	1	1	0	0	0	0	1	20.40	27.80	20.40	3.30	3.60	9.50	10.90	2.38	2.76
47.	Rajeswari	106439	1	1	1	1	1	0	0	1	19.30	22.30	22.30	3.10	3.30	8.20	10.20	2.05	2.43
48.	Shova Sinha	936278	0	1	1	0	0	0	1	1	21.40	22.30	22.00	3.10	3.30	8.00	9.70	1.68	2.00
49.	Selva Kumari	180539	0	1	1	1	0	0	0	1	28.00	29.30	19.50	3.50	3.70	10.10	11.20	2.04	2.33
50.	Sivagami	133394	1	1	1	0	0	0	1	1	21.20	23.10	22.00	3.00	3.20	7.40	9.60	2.14	2.54
51.	Saroj Yadav	833349	1	1	1	1	0	0	0	1	22.20	24.70	21.70	3.65	3.80	10.30	11.30	2.06	2.26
52.	Jebamani	691869	0	1	0	0	0	0	0	1	23.00	28.00	23.00	3.40	3.60	9.80	11.00	2.11	2.51
53.	Malar	188131	0	1	1	1	0	0	0	1	16.50	20.50	20.30	3.40	3.60	9.80	11.10	1.74	2.24
54.	Selvam	122287	0	1	1	1	0	0	0	3	26.70	26.70	23.80	3.40	3.70	10.10	11.30	1.90	2.05
55.	Jaikishan	802242	1	1	0	0	0	0	1	1	15.10	21.00	21.20	3.00	3.20	7.20	9.60	1.72	2.00
56.	Kannammal	987375	0	0	1	0	0	0	1	1	24.20	24.40	24.60	3.25	3.60	8.95	10.60	1.55	1.85
57.	Rose	254826	0	0	0	0	0	0	0	1	17.00	27.00	19.20	3.40	3.50	9.52	10.90	1.94	2.32
58.	Rizwanullah	055663	0	1	0	1	0	0	0	2	15.00	21.00	19.10	3.40	3.60	9.22	10.70	1.71	1.92
59.	Deviakiammal	853702	1	1	1	0	0	0	1	1	11.10	16.50	10.80	3.30	3.50	9.24	10.70	2.20	2.67
60.	Ramkumar	858695	0	0	0	0	0	0	0	1	17.00	28.00	19.30	3.30	3.80	10.10	11.30	2.36	2.78
61.	Rajeswari	991737	0	1	0	1	0	0	0	1	18.00	22.00	20.90	2.90	3.10	7.19	9.60	1.79	2.15
62.	Raji	793469	0	1	1	0	0	0	0	1	18.00	25.00	23.60	2.70	2.90	6.60	9.10	1.76	2.06
63.	Boobalan	838975	0	1	0	1	1	0	0	1	14.00	28.40	28.20	3.40	3.60	9.80	11.20	1.91	2.18
64.	Prema	904545	1	1	1	0	0	0	1	1	37.50	43.70	31.20	3.80	4.00	11.85	12.10	2.40	2.94
65.	Shyamal Patra	803969	1	1	1	0	1	0	0	2	33.10	42.70	37.20	4.10	4.20	13.78	13.20	2.14	2.47

66.	Vamathi	386556	1	1	0	1	1	0	1	1	28.40	38.00	31.40	4.10	4.20	13.44	13.10	2.03	2.65
67.	Nila Khatun	812113	1	1	1	0	0	0	0	1	28.20	36.70	32.60	3.90	4.10	12.46	12.50	1.96	2.42
68.	Deepti	814183	1	1	1	0	0	0	0	1	25.30	32.90	27.60	3.60	3.70	10.10	11.20	2.31	2.81
69.	Govindaraj	573966	1	1	1	1	0	0	0	1	25.80	30.80	27.50	4.40	4.50	15.82	14.10	2.39	2.84
70.	Veena Devi	812433	1	1	1	0	0	0	1	1	23.50	35.10	37.80	4.00	4.20	12.43	12.40	2.68	3.24
71.	Ananda Paul	953948	0	0	0	0	0	0	0	7	22.70	35.00	33.60	4.20	4.30	14.10	13.20	2.51	2.93
72.	Uthirakumar	773446	1	1	0	1	0	0	0	8	28.10	36.60	31.20	4.20	4.30	14.45	13.40	2.10	2.46
73.	Selvi	806969	0	1	1	0	0	0	0	4	52.00	57.50	42.00	3.50	3.60	10.10	11.30	1.91	2.49
74.	Simson Mochar	795883	1	1	0	0	0	0	0	6	37.00	42.00	33.90	4.20	4.30	14.45	13.40	2.07	2.64
75.	Harlin Rongha	770812	1	1	1	0	0	0	1	1	29.40	46.30	32.20	4.40	4.60	16.20	14.20	2.22	2.58
76.	Kalpana	815920	1	1	0	1	0	0	0	1	35.50	46.00	40.40	3.50	3.60	10.10	11.10	2.37	3.01
77.	Kamatchi	586712	0	1	1	1	0	0	0	9	36.50	39.00	32.00	4.50	4.50	15.50	14.20	2.26	2.68
78.	Anowar Bibi	789661	1	1	1	0	0	0	0	1	35.00	45.00	33.50	4.10	4.20	13.70	13.20	2.61	3.00
79.	Stella	601286	1	1	1	0	0	0	0	1	41.00	45.90	42.00	3.65	3.80	11.00	11.80	2.46	3.10
80.	Ramamurthy	423256	0	1	1	1	1	0	0	2	31.40	48.30	40.50	4.10	4.30	14.00	13.60	2.13	2.57
81.	Samsuddin Ansari	822130	1	1	1	0	0	0	0	6	38.80	48.90	47.30	4.00	4.20	13.40	12.80	2.41	3.08
82.	Sasipriya	824669	1	1	1	0	0	0	1	4	31.00	38.00	29.00	3.95	4.20	13.10	13.00	2.59	2.96
83.	Mamata Layek	772526	0	1	1	0	0	0	0	1	27.00	35.50	28.80	4.40	4.50	15.10	14.00	2.90	3.12
84.	Palani	936065	0	1	1	0	1	0	1	1	29.80	31.20	30.20	5.05	5.20	20.40	16.10	2.64	3.13
85.	Rani A	921834	1	1	1	0	0	0	1	1	31.30	42.00	31.00	5.60	5.70	25.30	18.10	4.02	4.37
86.	Sarada Devi	356600	1	1	1	0	0	0	0	1	29.50	35.80	30.00	4.20	4.40	14.70	13.30	2.57	3.01
87.	Kapuri Devi	651668	1	1	1	0	0	0	1	1	24.20	33.80	26.00	4.65	4.70	15.00	14.20	3.31	3.78
88.	Rani	836152	1	1	1	1	1	0	0	2	36.10	45.10	39.80	4.20	4.40	14.10	13.60	2.09	2.51
89.	Arup Middya	219451	1	1	1	1	1	0	0	3	34.20	37.90	35.20	4.20	4.30	13.20	13.10	2.47	2.70
90.	Janaki	329307	1	1	1	0	0	0	1	1	34.00	36.90	39.00	3.65	3.80	11.20	12.30	2.52	2.73
91.	Tapan Dutta	837082	1	0	1	0	1	1	0	7	31.30	43.00	34.60	3.80	4.00	13.20	13.00	2.11	2.35
92.	Jegan	925961	1	1	1	0	0	0	1	4	39.00	42.60	40.10	4.40	4.50	15.30	14.40	2.54	2.84
93.	Nagarani K	803520	1	1	1	1	0	0	0	1	23.00	34.20	27.80	3.90	4.10	12.10	12.70	2.71	3.10
94.	Usha	453241	1	1	1	1	0	0	0	1	29.00	35.00	29.30	3.90	4.00	10.70	12.80	2.38	3.06
95.	Mani	054550	1	1	1	0	0	0	1	1	30.20	36.90	34.10	4.40	4.50	15.70	14.40	2.42	2.72

96.	Jegadeesan	147654	1	1	1	0	0	0	1	1	35.10	40.60	36.30	4.30	4.40	13.00	13.50	2.36	2.66
97.	Navamani	664841	0	1	1	0	0	0	0	4	29.00	36.00	32.10	3.70	3.80	11.20	13.40	2.44	2.90
98.	Rajakumari	807061	0	1	0	0	0	0	0	4	44.30	47.00	38.30	3.50	3.70	10.30	11.30	2.56	3.02
99.	Poongavanam	629747	1	1	1	0	0	0	1	1	27.00	30.00	28.20	4.20	4.40	14.00	14.10	2.88	3.22
100.	Md Yacob	466714	1	0	0	0	0	0	0	1	28.40	41.90	33.90	3.90	4.10	12.20	13.20	2.05	2.37
101.	Nirmala Maji	711006	1	1	1	0	0	0	0	1	44.40	54.80	43.90	4.75	4.80	16.40	15.20	3.28	3.67
102.	Pushpa Bala	037380	1	0	0	0	0	0	0	1	27.20	40.30	20.20	4.10	4.30	13.40	13.40	3.00	3.53
103.	Kishun Saw	854086	1	1	1	0	0	0	0	1	34.00	39.90	34.10	4.15	4.30	12.70	15.20	2.19	2.56
104.	Roshin Bauri	851557	1	1	0	0	0	0	0	7	32.00	40.00	36.00	3.90	4.10	12.10	13.60	2.59	3.13
105.	Sakthivelmuru gan	805006	0	1	1	0	1	0	1	1	34.40	35.80	35.20	4.30	4.50	15.50	14.40	2.90	3.26
106.	Shahabaz Alam	818185	1	1	1	1	0	0	0	1	34.10	38.10	38.40	3.70	3.90	11.50	12.20	2.67	3.04
107.	Devaki	428989	0	1	1	1	0	0	0	1	23.90	31.40	36.00	4.00	4.20	13.10	12.80	2.15	2.47
108.	Swapan Pal	726332	1	1	0	0	0	0	0	6	29.20	31.80	31.60	4.50	4.60	16.50	14.70	2.55	2.80
109.	Subramani K	423622	0	1	1	1	1	0	0	3	29.00	32.60	30.80	4.45	4.50	15.10	14.30	2.44	2.84
110.	Uma	467241	1	1	1	0	0	0	1	1	30.50	36.30	28.70	3.90	4.00	11.80	13.10	2.37	2.67

Controls

	Name	ID	Age	Sex	Height	Weight	BSA	Rhythm	RVmid	RVBasal	RV long	RVEDA	RVESA	RVFAC	RVTei	IVA	TAPSE
1.	Idrish	839314	62	1	167	53	1.59	1.00	2.00	3.23	6.30	16.80	9.59	42.92	.47	7.19	2.42
2.	Bikram	854084	36	1	170	70	1.81	1.00	1.93	2.88	7.10	14.50	7.98	44.97	.53	4.87	2.22
3.	Pravas	846462	48	1	150	50	1.43	1.00	2.52	3.19	5.94	15.30	9.35	38.89	.50	3.59	2.31
4.	Damodaran	412671	54	1	160	48	1.48	1.00	2.54	3.24	5.99	13.90	7.77	44.10	.54	3.67	2.23
5.	shyamal	128811	55	1	160	60	1.62	1.00	2.21	2.91	6.83	11.90	8.60	27.73	.52	5.00	2.36
6.	Vijayalakshmi	847954	52	2	151	40	1.31	1.00	2.11	2.67	5.77	12.13	6.42	47.07	.51	3.70	2.19
7.	Asha singh	192234	54	2	150	57	1.51	1.00	1.91	2.55	6.22	11.80	6.23	47.20	.50	7.50	2.60

8.	Duli Rani	856200	47	2	152	50	1.45	1.00	2.31	2.81	5.89	13.00	8.26	36.46	.50	7.14	2.27
9.	Alice	460595	32	2	146	57	1.49	1.00	2.21	3.16	6.08	12.40	8.70	29.84	.51	6.00	2.06
10.	Achama	038065	63	2	148	63	1.57	1.00	2.54	3.16	5.69	13.30	7.67	42.33	.46	3.44	2.29
11.	Kamalakant	856699	65	1	155	60	1.59	1.00	2.18	3.37	5.60	13.80	7.30	47.10	.61	3.43	2.04
12.	Gangammal	563848	60	2	154	55	1.52	1.00	1.92	2.41	6.28	14.10	7.50	46.81	.52	5.71	2.31
13.	Takheyalyo	858833	52	2	147	43	1.32	1.00	2.38	3.06	6.54	13.70	7.99	41.68	.54	3.43	2.01
14.	Ruckmani	849764	55	2	146	43	1.32	1.00	2.10	2.58	5.26	10.80	6.60	38.89	.47	3.81	2.09
15.	Rajaul	794209	45	1	173	62	1.74	1.00	2.43	3.46	6.38	15.30	7.40	51.63	.52	4.00	2.06
16.	Ratan Paul	798188	43	1	167	67	1.75	1.00	2.70	3.40	5.80	17.00	11.40	32.94	.52	2.89	2.12
17.	Nitish Kumar	856546	22	1	169	65	1.75	1.00	2.65	3.60	5.90	19.20	10.10	47.40	.56	3.70	2.16
18.	Basant Yadav	854074	53	1	173	60	1.72	1.00	2.20	3.20	6.10	15.40	9.10	40.91	.50	3.33	2.56
19.	Piritosh	850648	60	1	179	67	1.84	1.00	2.40	2.90	6.10	10.40	7.40	28.85	.52	3.08	2.20
20.	Pritilata	859942	19	2	158	52	1.51	1.00	2.30	3.10	6.10	13.10	8.00	38.93	.52	4.00	2.20
21.	vibha lal	860138	37	1	155	70	1.69	1.00	2.56	3.57	5.68	16.30	8.27	49.26	.51	4.29	2.50

	Name	ID	TETH.H	LVLong	LVEDV	LVESV	LVEF	IVC	ESSI	ESEI	EDEI	LVSI	Heart RATE	Septolateral
1.	Idrish	839314	.15	7.47	94.40	34.70	63.24	1.10	1.52	1.97	1.99	4.65	88.00	2.90
2.	Bikram	854084	.18	7.07	101.90	41.30	59.47	2.08	1.12	1.86	1.86	5.84	88.00	3.30
3.	Pravas	846462	.13	6.82	72.10	29.60	58.95	1.02	1.57	1.94	1.87	4.34	86.00	3.10
4.	Damodaran	412671	.19	6.14	75.90	29.30	61.40	1.13	1.30	1.92	1.91	4.77	84.00	3.00
5.	shyamal	128811	.25	7.49	107.50	41.00	61.86	1.23	1.26	1.92	1.93	5.47	96.00	2.80
6.	Vijayalakshmi	847954	.24	6.84	85.80	35.00	59.21	1.36	1.11	1.88	1.92	5.12	98.00	2.70
7.	Asha singh	192234	.18	6.44	87.70	37.90	56.78	1.06	1.00	1.96	1.99	5.89	96.00	3.20
8.	Duli Rani	856200	.19	6.84	70.00	29.60	57.71	1.31	1.40	1.83	1.66	4.33	91.00	2.40

9.	Alice	460595	.17	6.89	87.70	36.40	58.49	1.50	1.43	1.86	1.74	5.28	84.00	3.00
10.	Achama	038065	.19	5.78	88.20	39.40	55.33	1.17	1.35	1.87	1.61	6.82	70.00	2.80
11.	Kamalakant	856699	.15	6.89	102.40	44.10	56.93	1.17	1.30	1.88	1.96	6.40	74.00	3.00
12.	Gangammal	563848	.24	7.74	72.10	31.40	56.45	1.48	1.19	2.15	1.94	4.06	88.00	3.00
13.	Takheyalyo	858833	.13	6.81	78.60	35.00	55.47	1.32	1.22	1.86	1.92	5.14	81.00	3.30
14.	Ruckmani	849764	.18	7.04	58.10	24.60	57.66	1.36	1.25	1.96	1.92	3.49	79.00	2.70
15.	Rajaul	794209	.16	7.20	102.40	44.10	56.93	1.31	1.16	1.91	1.95	6.13	65.00	3.10
16.	Ratan Paul	798188	.23	6.80	83.10	35.00	57.88	1.25	1.97	1.79	1.81	5.15	67.00	2.95
17.	Nitish Kumar	856546	.19	7.02	115.50	47.40	58.96	1.47	1.71	1.61	1.96	6.75	74.00	3.10
18.	Basant Yadav	854074	.14	6.90	87.70	37.90	56.78	1.18	1.49	1.83	1.76	5.49	87.00	2.80
19.	Piritosh	850648	.21	6.90	92.40	37.90	58.98	1.20	1.21	1.95	1.95	5.49	80.00	2.70
20.	Pritilata	859942	.17	7.16	65.90	24.60	62.67	1.25	1.31	1.91	2.03	3.44	81.00	3.00
21.	vibha lal	860138	.21	6.85	112.80	47.40	57.98	1.37	1.46	2.29	2.09	6.92	85.00	3.10

	Name	ID	Anteroposterior	TA Area	TA Perimeter	INDEXTAS	INDEXTAD
1.	Idrish	839314	2.60	6.70	9.30	1.45	1.64
2.	Bikram	854084	2.80	8.70	10.90	1.30	1.46
3.	Pravas	846462	2.70	8.00	.50	1.62	1.92
4.	Damodaran	412671	2.60	8.00	10.40	1.42	1.70
5.	shyamal	128811	2.40	6.20	8.90	1.38	1.53
6.	Vijayalakshmi	847954	2.35	7.00	8.80	1.79	2.00
7.	Asha singh	192234	2.70	7.30	9.70	1.40	1.64
8.	Duli Rani	856200	2.15	5.30	8.30	1.46	1.81

9.	Alice	460595	2.60	7.20	9.90	1.48	1.68
10.	Achama	038065	2.70	6.40	9.20	1.52	1.69
11.	Kamalakant	856699	2.60	7.10	10.00	1.61	1.87
12.	Gangammal	563848	2.70	6.80	9.10	1.24	1.47
13.	Takheyalyo	858833	2.70	7.10	9.60	1.79	2.01
14.	Ruckmani	849764	2.40	5.90	8.90	1.45	1.64
15.	Rajaul	794209	2.80	8.40	9.60	1.44	1.61
16.	Ratan Paul	798188	2.75	8.10	10.10	1.39	1.54
17.	Nitish Kumar	856546	2.80	8.70	10.20	1.29	1.60
18.	Basant Yadav	854074	2.65	7.42	9.60	1.36	1.52
19.	Piritosh	850648	2.40	6.50	8.80	1.14	1.28
20.	Pritilata	859942	2.60	6.30	9.20	1.46	1.64
21.	vibha lal	860138	2.70	7.40	10.10	1.32	1.60

ANNEXURE

PROFORMA: DATA ABSTRACTION FORM

Date of Enrolment: **Enrolment No:**

NAME: **AGE:** **SEX:** **1. Male / 2. Female**

ID NO: **DOB:**

ADDRESS:

PHONE: 1. **2.**

Indication for Transthoracic ECHO / Clinical diagnosis:

Height: **Weight:** **BSA:**

1. Sinus rhythm / 2. Atrial Fibrillation

NYHA functional class **1. I** **2. II** **3. III** **4. 1V**

Tricuspid Valve & Annulus Parameters

End-systolic TA diameter		Vena Contracta	
End-diastolic TA diameter		Peak TR Velocity	
Tricuspid Annulus Contraction%		TR jet area	
TAPSE		EROA	
TV Tethering height		TR Severity	
TV Tethering area			

Right Ventricular parameters

End-diastolic area		Systolic RV Pressure	
End-systolic area		Sphericity index	
Fractional area change		End-systolic EI	
RV Mid dimension		End-diastolic EI	
RV Long axis dimension		IVA=Peak isovolumic velocity/time to peak velocity	
RV Basal dimension		RV Tei index	

EI- eccentricity index

Pulmonary Valve Parameters

Estimated Systolic PA Pressure			

IVC & Hepatic Veins

IVC Dimension		IVC Collapse	
Systolic flow reversal hepatic veins			

Right Atrial Parameters

RA major dimension		Right atrial endsystolic area	
RA minor dimension			

Left Ventricular parameters

LV EDV		LV Long axis dimension	
LVESV		LV Spherical Index	
LVEF			

Clinical Parameters

Heart rate		NYHA Class	
Systolic BP		V Waves in JVP	
Diastolic BP		Typical Systolic murmur	
Diuretics		Edema	
Beta-blockers		Ascites	
ACEI		Pulsatile liver	
ARB		Sea-saw chest Movement	
CCB		Digoxin	

Three dimensional echocardiography parameters

Tricuspid annulus area		Anterior angle	
Tricuspid annulus perimeter		Posterior Angle	
Anteroposterior annulus dimension		Septal angle	
Septal lateral annulus dimension			

Miscellaneous:

INFORMED CONSENT FORM

CONSENT AND SIGNATURE

Please read the statements below, think about your choice, and sign if and when you are ready to agree, or take this form home and discuss it with anyone you wish to and then return it to us later if you wish to participate in this research:

The primary investigator has fully explained to me the nature and purpose of this research project in a way that I have understood. He has responded to all of my questions and concerns in a satisfactory and respectful way.

I have been offered opportunities to consult with an independent person, whom I trust, including a counselor or a physician, prior to my making my decision and has given me adequate time to decide.

I hereby give my voluntary consent to participate in the research project entitled Functional TR: Mechanisms and determinants of severity.

____________________________________Date:__________ ____________________________

Signature of Volunteer Name

____________________________________Date:__________ ____________________________

Signature of Person Obtaining Consent Name

PROJECT INFORMATION

- The participation in this study is entirely voluntary.
- There are no foreseeable physical risks for you in participating in this research project.
- Study does not involve any invasive procedures,
- This study is needed for research to learn more about the disorder in the hope of discovering new innovations of treatment.
- Although you may not benefit directly from the study, there is potential benefit to other patients in future.
- Your research and hospital records are confidential. The records of your involvement with this research project will be kept confidential. All records will be kept in a private database that can only be accessed by primary investigator. Any report that the researchers publish will not include any information that will make it possible for readers to identify you.
- The study will not affect the treatment being provided. There will be no additional charges for this study.
- You will not receive any cash or payment with goods or services for participation in this research project as that will affect the objectivity of the study.

Glossary for Master data chart

Key

- Sex: 1-Male 2- Female
- For V, murmur, edema, ascites, pulsatile liver, see saw chest, digoxin, beta blockers, ACEI, ARB, CCB, diuretics: 0- Absent 1- Present
- Dx: 1. Rheumatic heart disease. 2. Dilated Cardiomyopathy 3. Ischemic Cardiomyopathy 4. Primary pulmonary hypertension 5. COPD 6. Non rheumatic left valve disease 7. Cor pulmonale. 8. Porto-pulmonary hypertension 9. Hypertrophic cardiomyopathy

Abbreviations

ID : Unique Identification No of the patient.

ACEI : Angiotensin converting enzyme inhibitor

ARB : Angiotensinogen receptor blocker

Antero-posterior : Anteroposterior tricuspid annulus dimension

BSA : Body surface area

CCB : Calcium channel blocker

Dx : Diagnosis

ESSI : Right Ventricular spherical index

EDEI : Right ventricular end diastolic eccentricity index

ESEI : Right ventricular end systolic eccentricity index

EROA : Effective regurgitant orifice area

IVC : Inferior Vena Cava dimension

INDEX TAS : Indexed Tricuspid annulus end systolic dimension

INDEX TAD : Tricuspid annulus end diastolic dimension

LVEDV : Left ventricular end diastolic volume

LVESV	: Left ventricular end systolic volume
LVEF	: Left ventricular ejection fraction
LV long	: Left ventricular long axis dimension
LVSI	: Left ventricular spherical index
PASP	: Pulmonary artery systolic pressure
RAP	: Estimated right atrial pressure
RV Mid	: Right ventricular mid dimension
RV basal	: Right ventricular basal dimension
RV long	: Right ventricular long axis dimension
RVEDA	: Right ventricular end diastolic area
RVESA	: Right ventricular end systolic area
RVFAC	: Right ventricular fractional area change
IVA	: Isovolumic acceleration
Septolateral	: Septal-lateral tricuspid annulus dimension
TA	: Tricuspid annulus
TA area	: Tricuspid annulus area
TA Perimeter	: Tricuspid annulus perimeter
TASYS	: Tricuspid annulus end systolic dimension
TADIAS	: Tricuspid annulus end diastolic dimension
TAC	: Tricuspid annulus contraction
TAPSE	: Tricuspid annulus plane systolic excursion
TETH.A	: Tethering area
TETH. H	: Tethering height
V	: V waves in JVP
VC	: Vena Contracta

Glossary and List of Abbreviations

ACC	:	American College of Cardiology
AF	:	Atrial Fibrillation
AHA	:	American Heart Association
ANOVA	:	Analysis Of Variance
AVN	:	Atrioventricular node
ASE	:	American Society of Echocardiography
CS	:	Coronary sinus ostium
DCMY	:	Dilated Cardiomyopathy
EI	:	Eccentricity index
ESC	:	European Society of Cardiology
FO	:	Foramen ovale
IVA	:	Isovolumic Acceleration
IVC	:	Inferior Vena Cava
LA	:	Left Atrial
LV	:	Left Ventricle
MPI	:	Myocardial performance Index
MR	:	Mitral regurgitation
NYHA	:	New York Heart Association
PISA	:	Proximal Isovelocity Surface Area
PASP	:	Pulmonary Artery Systolic Pressure
RA	:	Right atrium
RV	:	Right Ventricle
RVSP	:	Right Ventricular Systolic Pressure
TV	:	Tricuspid Valve
TR	:	Tricuspid regurgitation

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